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THE EFFECT OF SHIPBOARD DESIGN DECISIONS IN AMPHIBIOUS WARFARE

by

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June 2012

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Recently, a major decision was made by the Navy to eliminate a key capability from the future ship of the amphibious fleet. The removal of the well deck from the future LHA (R) amphibious assault ship is attempting to change the way the Navy and Marine Corps have conducted amphibious operations over the past several decades. This thesis will look at the current and future amphibious capabilities in order to develop equations to quantitatively analyze the lift capabilities associated with future design choices to determine the effects of changing the design in the LHA (R) class of amphibious assault ships. A comparative analysis of the tradeoffs, capabilities, and limitations associated with and without having a well deck was completed in order to determine the most effective means to operate. By looking at data on the MV-22 *Osprey* and F-35 Joint Strike Fighter, such as lift capabilities and ranges, and comparing it to the various landing craft data (LCACs, LCUs and AAVs), this thesis will determine the effects on mission capabilities of the Navy and Marine Corps.

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THE EFFECT OF SHIPBOARD DESIGN DECISIONS IN AMPHIBIOUS WARFARE

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Recently, a major decision was made by the Navy to eliminate a key capability from the future ship of the amphibious fleet. The removal of the well deck from the future LHA (R) amphibious assault ship is attempting to change the way the Navy and Marine Corps have conducted amphibious operations over the past several decades. This thesis will look at the current and future amphibious capabilities in order to develop equations to quantitatively analyze the lift capabilities associated with future design choices to determine the effects of changing the design in the LHA (R) class of amphibious assault ships. A comparative analysis of the tradeoffs, capabilities, and limitations associated with and without having a well deck was completed in order to determine the most effective means to operate. By looking at data on the MV-22 *Osprey* and F-35 Joint Strike Fighter, such as lift capabilities and ranges, and comparing it to the various landing craft data (LCACs, LCUs and AAVs), this thesis will determine the effects on mission capabilities of the Navy and Marine Corps.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAV	Amphibious Assault Vehicle
ACE	Air Combat Element
ARG	Amphibious Ready Group
ATF	Amphibious Task Force
C4I	Command, Control, Communications, Computers and Intelligence
CATF	Commander, Amphibious Task Force
CJCS	Chairman of the Joint Chiefs of Staff
CLF	Commander, Landing Force
CLOP	Capability/Cargo Left On Pier
DoD	Department of Defense
EDL	Equipment Density List
EMCON	Emission Control
ESG	Expeditionary Strike Group
HMMWV	High Mobility Multipurpose Wheeled Vehicle
JCIDS	Joint Capabilities Integration and Development System
JFC	Joint Force Commander
JP-5	Jet Propellant Fuel
JROC	Joint Requirements Oversight Council
JSF	Joint Strike Fighter
LAV	Light Armored Vehicle
LCAC	Landing Craft Air Cushioned
LCU	Landing Craft Utility
LF	Landing Force

LHA	Amphibious Assault Ship (General Purpose)
LHA (R)	Amphibious Assault Ship, Replacement
LHD	Amphibious Assault Ship (Multipurpose)
LPD	Amphibious Transport Dock
LPH	Amphibious Assault Ship (Helicopter)
LSD	Dock Landing Ship
MAGTF	Marine Air Ground Task Force
MEB	Marine Expeditionary Brigade
MEU	Marine Expeditionary Unit
MIO	Maritime Interdiction Operations
NAVSEA	Naval Sea Systems Command
NEO	Non-combatant Evacuation Operations
OMFTS	Operational Maneuver from the Sea
PCU	Pre-Commissioned Unit
PHIBRON	Amphibious Squadron
RDT&E	Research, Development, Test, and Evaluation
ROWPUS	Reverse Osmosis Water Purification Unit
SSN	Attack Submarine, Nuclear
STOM	Ship to Objective Maneuver
STOVL	Short Takeoff/Vertical Landing
TOW	Tube Launched, Optically Tracked, Wire Guided
TRAP	Tactical Recovery of Aircraft and Personnel

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I. INTRODUCTION

A. DISCUSSION AND PURPOSE

Amphibious warfare has always played a vital role in missions and operations for the United States Navy and Marine Corps. Both services have come together, particularly during and after World War II, to develop unique and specific amphibious concepts and principles along with specialized ships and equipment to perform a variety of amphibious missions that no other force in the world can rival. Recently, a decision was made by the Navy to eliminate a major capability from the future ship of the amphibious fleet. With a shift in design to eliminate the well deck in the new LHA (R) *America* class of amphibious assault ships, Navy and Marine Corps amphibious warfare capabilities and concepts are being forced to fit into a new system. Recent operations in Iraq and Afghanistan have pushed for an enhanced aviation capability on board LHAs and LHDs, which began the shift in thought and design for the new LHA (R). The issue here is that the shift in design solves the current problems only and does not look beyond the Middle East to future conflicts. As stated by retired Marine Major-General William Whitlow on the new class of amphibious ships:

> The LHA-R should be capable of handling legacy air assets and future ones that are different size and weight. It should have the ability to switch out modules to convert into a command and control ship. It should not be a single-purpose ship. An aviation-only capable ship would be very short sighted. Any future ship should be built from the keel up to be able to adapt to a myriad of capabilities. (Sullivan 9)

The United States military prides itself as being the most capable, flexible and strongest force in the world. While design decisions may be costly, it should not limit the warfighter and be the sole criteria in decision making. Limiting our capabilities while foreign and non-state actors become stronger and more unpredictable will negatively impact our forces; therefore it is necessary to analyze these affects and make appropriate recommendations for future designs.

A full analysis on the elimination of the well deck and a reduction in capabilities on board the new *America* class amphibious assault ships was never conducted in the program's original Analysis of Alternatives study performed by the Center for Naval Analyses or looked at once the final design was approved. The Navy and Marine Corps are now scrambling to understand how these new design decisions will affect the amphibious fleet and future missions while the first ship in the *America* class is being constructed. The purpose of this thesis is to supplement the research and analysis currently being done on this subject and to rigorously investigate General Whitlow's assertion in order to determine how this will affect the capabilities of the Navy and Marine Corps and ultimately recommend a proposed amphibious model.

B. RESEARCH QUESTIONS

The primary focus of this thesis is to answer the question of how a shift in amphibious warfare design decisions will affect military capabilities. Specifically, this thesis will look at how losing the well deck capability in the newly designed LHA (R) *America* class will affect operational mentality and mission capability in amphibious warfare. A secondary question this thesis will answer is how design decisions are made in the Department of Defense in order to uncover why such a critical capability was eliminated in the future amphibious assault ship.

C. RESEARCH METHODOLOGY

The main research method used to develop this thesis was an extensive literature review of books, government reports and studies, and Internet articles. Personal interviews with key personnel in the amphibious warfare field of expertise were also conducted to gain firsthand knowledge and gather data. Once all of the data were collected, a comparative analysis was performed on the current and future amphibious capabilities in order to develop lift equations to quantitatively determine the effects of changing the design of amphibious assault ships. From the analysis results a recommended amphibious model is proposed.

D. ORGANIZATION

This thesis is organized into the following chapters:

- Chapter I is the introduction and describes the overview of the thesis.
- Chapter II provides background information on amphibious warfare, reviews key amphibious warfare doctrine, and discusses the current LHA lift capabilities and configurations.
- Chapter III describes the changes in organizational amphibious design with an overview of the new LHA *America* class lift capabilities and configurations. This chapter also discusses how design decisions are made by exploring the Department of Defense's acquisition life cycle and reviews previous design models to develop lessons learned.
- Chapter IV discusses the results of the comparative amphibious model data analysis. The lift equations are developed in this chapter to assess the impacts of the design change and provide a proposed amphibious model.
- Chapter V provides the research conclusions and recommendations for future work in this topic.

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II. BACKGROUND

A. INTRODUCTION

The United States military has been conducting amphibious operations since the Battle of Nassau during the Revolutionary War in 1776, to the shores of Tripoli at the Battle of Derna in 1805, and during the Mexican-American War at the Battle of Chapultepec in 1847 (“History: A Commitment to Our Nation Since 1775”). However, it was during World War II in which the Navy and Marine Corps established concepts and doctrine for what is known today as modern amphibious warfare tactics, techniques, and procedures (Jacob 2). The war in the Pacific was truly a naval battle fought between two super powers in which amphibious operations proved to be the essential element necessary to propel the United States to victory. The great battles fought at Midway, Coral Sea, Iwo Jima, Guadalcanal, and Okinawa shaped the Navy and Marine Corps’ amphibious doctrine to what it is today (“World War II-Asiatic-Pacific Theater 1941–1946”).

Although both Japan and Germany sought hegemony in their areas of the world, it is only the United States that developed a significant amphibious capability. Japan and the U.S. had quite different approaches to amphibious raids, landings, and assaults. Before the U.S. entered World War II, Japan was able to extend their empire across the entire Pacific Ocean relatively unopposed, which in all probably led them to developing such benign tactics. Surprisingly too that it was the Japanese Army and not the Imperial Navy that took the lead and established crude amphibious warfare tactics. Unlike the U.S., Japan never developed and specialized in amphibious ships or craft as their doctrine remained true to favoring the use of carriers and aircraft to battle enemy forces. Japan is a particularly interesting case in that their ambitions in the Pacific would require the landing of significant occupational forces yet they ignored the proven concepts of amphibious raids, landings, and assaults as a means of inserting troops into hostile areas. The United States, on the other hand, entered the war with Japan already settled in bases and established throughout the islands of the Pacific. It would be the destiny of the U.S.

naval forces to develop amphibious warfare concepts as the Allied troops stormed from island to island in the Pacific theater. Therefore, the U.S. had a distinct requirement to create and seize advanced naval bases from enemy territory and alone identified the need to conduct opposed amphibious landings (Millett 50–59). The key element of success for the United States was the Marine Corps, as they were the highly trained, mobile, and agile force that would lead this island hopping campaign across the Pacific Imperial Empire. The U.S. applied a direct approach to war by attacking Japan's strengths, seeking out their main forces, and destroying them. The Marine Corps' amphibious doctrine emphasized daylight, early morning assaults, vice the traditional surprise night attacks, in order to maximize the hours of daylight to establish the beachhead. Traditional thinking centered on surprise and chaos during night attacks. The U.S., however, eschewed that policy and showed little interest in the element of surprise. Their focus shifted to the maximum use of strategic and operational resources, such as shore bombardment, strategic bombing, massing of troops, and overwhelming firepower to destroy the enemy. Since the terrain in the Pacific islands made it almost impossible to avoid Japanese main bodies of defense, opposed landings accompanied with a pre-invasion bombardment became routine for the U.S. landing forces. It was under these conditions that led the U.S. Navy and Marine Corps developed the foundation of today's conduct of amphibious operations ("WWII Amphibious Warfare").

The years following World War II led to the United States further developing and specializing in what are today's amphibious assault ships, the LHA (Amphibious Assault Ship, General Purpose) Class and LHD (Amphibious Assault Ship, Multipurpose) Class. Each brought a versatile asset to the fleet by allowing Naval and Marine forces to sail into harm's way and provide a rapid buildup of combat power ashore in the face of the adversary ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). The U.S. is the leading world power when it comes to developing and designing amphibious assault ships and in conducting a variety of amphibious operations. Currently, no other country in the world has a better trained and equipped amphibious fleet than the United States Navy and Marine Corps. While world powers, such as the United Kingdom, China, Russia, and France each have a naval force with amphibious capabilities, none rival the U.S. fleet, making it the best and most unique on the planet. The recent wars and conflicts in the Middle East have created a shift in military thinking as the enemy has become less and less accessible to coastal forces causing many countries to move away from traditional amphibious landings. The British have scaled down their amphibious fleet in recent years, having only two large deck amphibious ships at their disposal. The Royal Marines have been greatly reduced while amphibious training has become nonexistent ("IHS Jane's: Defense & Security Intelligence & Analysis"). France has maintained a small fleet of amphibious assault ships, numbering two *Foudre* class Amphibious Transport Docks (LPDs) and two *Mistral* class LHDs. Missions of the French amphibious fleet center on humanitarian and non-combatant evacuation operations (NEO) and have little to no involvement in combat missions (Annati 1–2, 7–8). Post-Cold War Russia does not have an amphibious capability but is taking a radical step in purchasing several *Mistral* class LHDs from the French over the next decade. Russia has bought into the amphibious capability in order to control and protect their country's vast littoral regions and to spark their troubled shipbuilding industry ("Russia Orders French Mistral Amphibious Assault Ships"). China is also making improvements to their fleet with the addition of several *Yuzhao* Type 071 amphibious vessels to their arsenal, which resemble a U.S. LPD. The roles these vessels are expected to play in include humanitarian aid and disaster relief, maritime security operations, and NEO (O'Rourke 25–27). Figure 1 shows a graphical representation of the number of major mission area amphibious ships that the United States, United Kingdom, France, China, and Russia have had in service from 1980 and projected out to 2020. Landing craft utilities (LCUs) were included in China's amphibious ship count because their current amphibious strategy involved the use of LCUs as a major mission area ship that had self-sustaining capabilities for several weeks patrolling coastal waters.

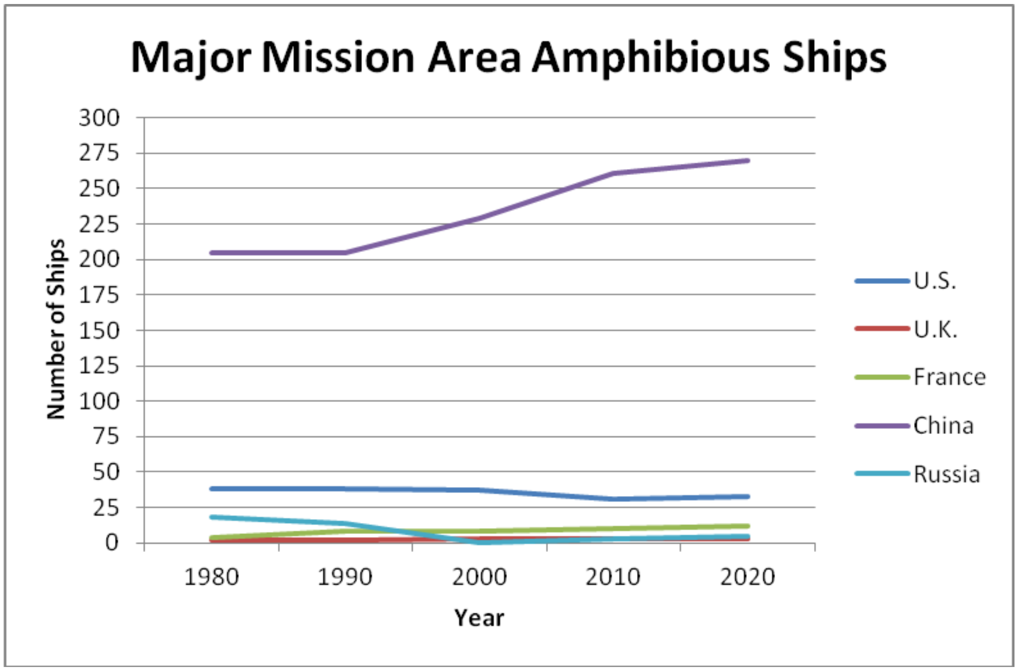

Figure 1. Major Mission Area Amphibious Ships (After "IHS Jane's: Defense & Security Intelligence & Analysis").

In comparison with the other world super powers, the U.S. has a vast amphibious force, numbering 31 active ships in service. The U.S. amphibious assault ships are involved in a variety of operations, from projection of power and combat operations to humanitarian aid and NEO. The unique, multipurpose capabilities of amphibious assault ships are why they can be tasked with a wide variety of missions. Projection of power and combat operations are the primary tasks of the U.S. amphibious assault ships. Projection of power from a Navy and Marine Corps standpoint means to deploy assets overseas to areas of interest that are typically inaccessible in order to intimidate or deter nations from conducting any egregious acts. Examples of projection of power missions include routine deployments to the Persian Gulf that show U.S. presence in an area of conflict. Projection of power missions may turn into combat operations if hostilities escalate in which Navy and Marine Corps forces would already be in a strategically placed environment to conduct offensive operations of landing the Marines ashore. What makes the U.S. amphibious fleet such a distinctive, dominant force is their ability to sail anywhere in the world, deter aggression, access impenetrable areas, and defend and protect sea lanes for shipping and transport worldwide. The ability to reach an area without proper port facilities around the globe is what makes the United States Navy and Marine Corps the most capable and credible force in the world.

While the primary mission of amphibious assault ships is to conduct amphibious operations by transporting Marines and their equipment to the combat area, secondary missions include humanitarian aid and disaster relief in large part because of their various resources and assets, such as having a large medical facility on board and ability to transport and store a large amount of supplies and equipment ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). Humanitarian missions have aided a countless number of people around the world, especially these areas impacted by natural disasters. Amphibious assault ships were first on the scene following the earthquake and tsunami in Japan in 2011, took charge at home off the coast of New Orleans, Louisiana after Hurricane Katrina ravished the area in 2005, and were there supporting Thailand and the Philippines after the deadly earthquake and tsunami in 2004. It was the amphibious fleet that had the ability to help these devastated areas because they could easily gain access to ports that were no longer functional and operate where ports no longer existed. With the rise in number of routine and emergency humanitarian operations, the U.S. Navy is certainly living up to its image as a "Global Force for Good." While the Navy may not be conducting ship to ship gun battles on the high seas or performing opposed amphibious landings on the isles of the Pacific on a daily basis in this era of conflict, the humanitarian operations they are performing day after day preserve peace and security while preventing chaos and terrorism from reigning.

Over the past twenty years, both LHAs and LHDs have been tasked with more humanitarian operations than combat operations. As seen in Table 1, of the 130 primary mission types assigned to LHAs and LHDs from 1979 to 2006, 32 were humanitarian (24%) and 20 were combat (15%). Projection of power, one of the United States military's main objectives, was the most assigned mission, numbering 43 (33%). Tables 2 and 3 break these figures down into two separate time frames: Cold War era operations from 1979 to 1991 and Post-Cold War era operations from 1992 to 2006. During the Cold War period, humanitarian operations totaled the highest with 10 (33%), projection of power was second with nine (30%), and combat operations was third with a total of four (13%). The Post–Cold War period saw a dramatic increase in number of operations due to various conflicts and operations in the Middle East and following the attacks on 11 September 2001. Power projection operations rose to the highest spot numbering 34 (34%), followed by humanitarian operations at 22 (22%), and combat operations at 16 (16%) (McCarton B-1–B-7). One possible explanation for the rise in humanitarian operations is the unfortunate number of disasters occurring around the world and the United States being able to send in relief, aid, and assistance by utilizing the Navy and Marine Corps assets. Because of their versatile capabilities, including the combined ability to conduct air and landing craft operations, their ability to reach inaccessible ports, and operate without port facilities, amphibious assault ships have been traditionally assigned the humanitarian task. The emphasis on humanitarian operations has also renewed and validated the need for America's Navy to have and maintain a significant amphibious capability to support the "Global Force for Good" claim in order to continue to supply aid and relief around the world. These data also show that amphibious assault ships have had significant contributions to the wars of the past two decades, specifically in Desert Shield/Desert Storm, Operation Iraqi Freedom and Operation Enduring Freedom. The other primary operational category types that LHAs and LHDs were assigned can be seen in Table 1. The capability of dual air and landing craft operability allows amphibious assault ships to accomplish all of these various missions and will be a reoccurring theme throughout this thesis.

Table 1. Operations from 1976–2006 (After McCarton B-1–B-7).

Operations From 1976 to 2006		
Operation Type	**Number of Operations**	**Percent (%)**
Power Projection	43	33
Humanitarian	32	24
Combat Operations	20	15
Special Operations	8	6
Maritime Interdiction Operations	6	5
Surge Deployment	6	5
Law Enforcement	5	4
Noncombatant Evacuation Operations	5	4
TRAP Operations	4	3
Peacekeeping	1	1
Total	130	

Table 2. Cold War Operations from 1979–1991 (After McCarton B-1–B-7).

Operations From 1979 to 1991		
Operation Type	**Number of Operations**	**Percent (%)**
Humanitarian	10	33
Power Projection	9	30
Combat Operations	4	13
Law Enforcement	3	10
Special Operations	2	7
Noncombatant Evacuation Operations	1	3.5
Surge Deployment	1	3.5
Total	30	

Table 3. Post-Cold War Operations from 1992–2006 (After McCarton B-1–B-7).

Operations From 1992 to 2006		
Operation Type	**Number of Operations**	**Percent (%)**
Power Projection	34	34
Humanitarian	22	22
Combat Operations	16	16
Maritime Interdiction Operations	6	6
Special Operations	6	6
Surge Deployment	5	5
Noncombatant Evacuation Operations	4	4
TRAP Operations	4	4
Law Enforcement	2	2
Peacekeeping	1	1
Total	100	

Sent out to accomplish these missions and operations are the LHA and LHD amphibious assault ships, which are the largest warships of their kind in the world. The purpose of these ships is to carry Marines and their equipment and supplies to the amphibious assault objective area and support the Marine Corps tenets of Operational Maneuver From the Sea (OMFTS) and Ship to Objective Maneuver (STOM). The three classes of amphibious assault ships, or "big deck amphibs," are the LHA *Tarawa* class, LHD *Wasp* class, and LHA (R) *America* class. Each ship in service from the classes can be seen in Tables 4, 5 and 6. The ships of the LHA *Tarawa* class are the oldest of the amphibs and have only two ships remaining in service. The LHD *Wasp* class has eight ships in service. The third and newest LHA (R) *America* class will have its first ship in service by 2013, *USS America*, LHA 6 ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

Table 4. LHA Tarawa Class (After "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

LHA *Tarawa* Class	
Hull Number	**Name**
LHA 4	*USS Nassau*
LHA 5	*USS Peleliu*

Table 5. LHD *Wasp* Class (After "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

LHD *Wasp* Class	
Hull Number	**Name**
LHD 1	*USS Wasp*
LHD 2	*USS Essex*
LHD 3	*USS Kearsarge*
LHD 4	*USS Boxer*
LHD 5	*USS Bataan*
LHD 6	*USS Bonhomme Richard*
LHD 7	*USS Iwo Jima*
LHD 8	*USS Makin Island*

Table 6. LHA (R) *America* Class (After "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

LHA (R) *America* Class	
Hull Number	**Name**
LHD 6	*USS America*
LHD 7	TBD
LHD 8	TBD

LHAs and LHDs resemble small aircraft carriers and have the capability to conduct both rotary wing and fixed wing aircraft operations. Typical rotary wing aircraft, or helicopters, that are able to fly on board and be maintained by the crew include CH-46 *Sea Knights*, CH-53 *Sea Stallions*, UH-1 *Hueys*, AH-1 *Super Cobras*, MH-60 *Seahawks*, and MV-22 *Ospreys*. Currently, the only fixed wing aircraft, or strike fighter jet, that can embark on board amphibious assault ships are AV-8B *Harriers* since they have the ability to take off on a shorter flight deck and land vertically. Amphibious ships do not have a catapult or arresting wire system like those on an aircraft carrier and require fixed wing aircraft to take off on their own power and land vertically back on the flight deck ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA[R]"). Replacing the *Harrier* jet in the near future will be the F-35 Joint Strike Fighter in which the Marine Corps variant will be capable of a vertical/short take-off and landing. In terms of lift and transport of equipment, the CH-46 *Sea Knight*, CH-53 *Sea Stallion*, and MV-22 *Osprey* are the work horse of the Marine Air Combat Element (ACE). Each helicopter has the ability to carry combat ready Marines and transport a light to medium load of equipment and supplies from ship to shore. All are also very useful during humanitarian aid and disaster relief operations with the transport of supplies and personnel along with the ability to fly over inaccessible areas to perform reconnaissance and search and rescue. The AH-1 *Super Cobra*, AV-8B *Harrier*, and F-35 Joint Strike Fighter are the fire power of the Marine ACE. They are the strike aircraft that perform close air support for ground troops and battlespace preparation and bombardment for amphibious landings. The fighter aircraft do not have any lift or transport capabilities and would therefore are not considered an asset in humanitarian operations.

The characterizing versatile asset of amphibious assault ships is their ability to operate aircraft and landing craft simultaneously due to a large flight deck and floodable well deck. While flight decks of all sizes are common amongst warships, the well deck is the defining feature of amphibious ships. Well decks are large, open areas located at the waterline of ships that can be flooded using ballast tanks to allow smaller water craft to enter and leave the ship. They were added to the design of the first purpose-based amphibious assault ship, the LHA, in the 1970s in order to best aid the Marines in getting ashore by air and sea (Harrison 1). The various landing craft made for amphibious ship well decks include Landing Craft Air Cushioned (LCACs), Landing Craft Utilities (LCUs), and Amphibious Assault Vehicles (AAVs) ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). LCACs, LCUs and AAVs are all means in which Marines and their equipment can travel ashore. LCACs are high speed craft that use a cushion to hover on top of the water and over beaches to transport personnel, weapons, equipment, and cargo from ship to shore ("United States Navy Fact File: Landing Craft, Air Cushioned"). LCUs, resembling the landing craft used in World War II, also transport Marines, equipment and cargo ashore but at much lower speeds ("United States Navy Fact File: Landing Craft, Mechanized and Utility (LCM/LCU)"). AAVs are armored amphibious vehicles used to transport combat equipped Marines ashore in hostile environments ("AAV-7 Amphibious Assault Vehicle"). In terms of lift, the landing craft carry all the heavy equipment and vehicles from ship to shore. LCACs and LCUs are vital to amphibious operations as they can transport all the necessary equipment and supplies ashore while personnel are being delivered by helicopter. AAVs supply armor and defensive firepower as they head towards shore in hostile environments and provide the ground element as a troop transport carrier once on land. LCACs and LCUs are also key assets in humanitarian operations as they too can reach inaccessible areas of ports, transport supplies and personnel to and from the ship, and maneuver in the shallow littorals and coastal waters. AAVs would not be the ideal landing craft to use in humanitarian aid since it is a combat vehicle. Plus LCACs and LCUs have a larger carrying capacity, maneuver at greater speeds, and are typically a more reliable asset. The ability of amphibious assault ships to perform landing craft and aircraft operations at once or separately is what makes this an advantageous asset for the Navy and Marine Corps to use in any environment. If flying conditions are poor and helicopters are not an option, then landing craft may be able to accomplish the mission and vice versa. The well deck in combination with the flight deck is what makes the amphibious assault ship the most resourceful and flexible platform in the Navy's arsenal.

The new *America* class LHAs that will replace the aging *Tarawa* class LHAs, will, however, be a different breed of amphibious assault ships. The well deck, the defining amphibious ship feature, will not be included in the construction of LHA 6 and LHA 7. Instead, the *America* class will rely solely on aviation capabilities to land Marines ashore. The new amphibious platform will be able to embark the typical rotary and fixed wing aircraft, but the majority will be the MV-22 *Osprey* and F-35 Joint Strike Fighter, which does not allow for continuous lift of personnel, equipment, cargo and vehicles ashore ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). This is a dramatic shift in amphibious assault ship design and will alter the way amphibious operations are planned and executed from both a Navy and Marine Corps point of view. The shift in amphibious design decision is the focus of this thesis and will determine how the Navy and Marine Corps will be affected by losing a critical capability they have come to rely on for decades.

B. DOCTRINE

A key component in the United States' development of amphibious warfare tactics is the establishment of written doctrine, policies, and principles that direct the warfighters in battle. Military doctrine defines and describes the best way to conduct operations and acts as a guide for military forces to support national objectives (*Joint Publication 1–02: Department of Defense Dictionary of Military and Associated Terms* 102). Doctrines are living documents that can be modified and updated to reflect the changing world to incorporate new tactics, techniques, and procedures. In amphibious warfare, the three key doctrinal pieces that guide planning and execution of amphibious operations are 1) Operational Maneuver from the Sea (OMFTS), 2) Ship-to-Objective Maneuver (STOM), and 3) the Joint Doctrine for Amphibious Operations. Each reflect the current model of conducting amphibious operations and represent the conceptual organizational design and capabilities required to accomplish amphibious warfare missions. Specifying the classification of missions assigned to amphibious assault ships is the guidance set forth in the directives by President Barack Obama in the 2010 National Security Strategy and are reflected in the 2011 National Military Strategy.

1. Operational Maneuver from the Sea (OMFTS)

The development of the OMFTS concept is a way for the Navy and Marine Corps to meet the challenge of "chaos in the littorals," or coastal waters, and winning decisive victories in these areas of conflict where land and water meet. OMFTS relies on the ability to maneuver naval forces at the operational level directly against the enemy's center of gravity in order to exploit the adversary's weakness and deliver a decisive blow. The operational level of war is where major operations and campaigns are planned, conducted, and sustained to achieve strategic objectives within theaters or operational areas (*Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* 252). The enemy's center of gravity is their source of power that provides moral or physical strength and allows them the freedom and/or will to act (*Joint Publication 1–02: Department of Defense Dictionary of Military and Associated Terms* 46). The enemy's center of gravity, however, may not always be accessible from the sea, as seen in today's conflict in Afghanistan. Amphibious operations and the OMFTS principles would obviously not be the first choice in military strategic planning for conducting offensive maneuvers in a land-locked area like Afghanistan, but can aid in a supporting role by transporting troops and equipment overseas to the area of conflict.

The defining characteristic of OMFTS is the extensive use of the sea to gain the upper hand by using it as a means of friendly movement while creating a barrier to the enemy. Examples of this concept include sea-based logistics and sea-based fire support along with using the sea for tactical and operational movement (*Operational Maneuver from the Sea* 5). As improvements in equipment, technological advances in weapon systems, and decreases in fuel requirements in land vehicles continue, it will result in a decreased need to form beachheads for supply facilities ashore and allow for a faster ship-to-shore movement without the traditional “operational pause” to arrive at the objective area at a much greater pace (*Operational Maneuver from the Sea* 5–6). This is an important concept of OMFTS because it will keep the enemy from regrouping, allow friendly forces to maintain pressure, and not expose friendly supply chains for the enemy to exploit, compromise, or destroy. Improvements and advancements in weapon systems, equipment, and vehicles directly affect amphibious operational requirements as it allows for a smoother transition from ship to shore in which there is greater stability in the establishment of the beachhead in both a combat and logistic sense. Decreasing the supply footprint ashore removes a critical vulnerability and allows the landing force to continuously press forward and pressure the enemy. The six principles of OMFTS focus on this concept of matching strength against weakness to overwhelm and pressure the adversary. The six principles are:

- OMFTS focuses on an operational objective.
- OMFTS uses the sea as maneuver space.
- OMFTS generates overwhelming tempo and momentum.
- OMFTS pits strengths against weakness.
- OMFTS emphasizes intelligence, deceptions, and flexibility.
- OMFTS integrates all organic, joint, and combined assets.

The most crucial and often the most difficult aspect to integrate into the OMFTS principles is a command and control system that can execute rapid decision making at all levels and demonstrate the ability to operate with speed and flexibility that ultimately translates into a high operational tempo (*Operational Maneuver from the Sea* 6). Success of OMFTS relies heavily on the Navy and Marine Corps team’s ability to conduct an overwhelmingly fast-paced amphibious operation that will overpower the enemy before they can react and ultimately deter and/or discourage them from fighting.

The current LHA and LHD class of amphibious assault ships fit into the OMFTS objectives because of their versatility and mission objectives which enable response throughout the spectrum of conflict from combat to humanitarian operations (Jacob 7). Therefore, it is crucial “that naval forces avoid a narrow definition of their capabilities” (*Operational Maneuver from the Sea* 5) and not put restrictions on how the OMFTS capable forces operate. Contrary to this objective, the *America* class will hinder the operational tempo that OMFTS relies on since the ship lacks the capability to conduct simultaneous movement of equipment, supplies, vehicles, cargo, and personnel ashore. Each phase of movement will take longer because the various helicopters are limited in amount of lift capacity ("LHA-6/LHD-1: ESG Lift Comparison" 8–18). This in turn will create an undesired operational pause in between phases and defeat the purpose of OMFTS altogether.

2. Ship-to-Objective Maneuver (STOM)

STOM is the tactical implementation of OMFTS that can be applied to all types of amphibious operations to overcome access challenges, gain entry, and achieve favorable results on land (*Ship-to-Objective Maneuver* 1). The purpose behind the STOM concept is to apply maneuver warfare to amphibious operations at the tactical level to allow the Joint Force Commander to directly attain mission objectives (Jacob 9). As with OMFTS, STOM focuses on amphibious forces operating across a multitude of different types of areas in the uncertain and complex littorals while addressing several different objectives with the same general-purpose force (*Ship-to-Objective Maneuver* 2). The central idea of STOM is to "facilitate credible responses to crises in the littorals with tailored, scalable forces in permissive, uncertain and hostile environments that will enable successful engagements, humanitarian assistance, crisis response, and power projection" (*Ship-to-Objective Maneuver* 4). Essentially, STOM is about gaining access to the littorals and allowing naval forces to operate in a more decentralized manner to accomplish mission objectives directly at a faster rate (*Ship-to-Objective Maneuver* 4).

The STOM principles will allow amphibious forces to accomplish a wide variety of tasks and goals by exploiting vast improvements in speed, range, and command and control along with eliminating the transition at the water's edge to advocate a seamless littoral maneuver. Achieving this goal will require additional advanced unit level training that will empower the Marine Air Ground Task Force (MAGTF) to use more sophisticated forms of soft and hard power capabilities in the complex littoral environment. The following lists the 11 tenets of STOM and what the amphibious forces will be more capable of doing with the implementation of these principles (*Ship-to-Objective Maneuver* 4–8):

- Conduct littoral maneuver while using the sea as a protective barrier and highway for logistics and to outflank the enemy.
- Application of the single-battle concept and treatment of the battlespace as an indivisible entity.
- Improve options for the Joint Force Commander by having a readily available force at all times within the operating area.
- Use of seabasing to limit the footprint ashore and diminish the operational pause following troop landing.
- Focus equally on soft and hard power missions (from combating hostile engagements to Noncombatant Evacuation Operations, NEO, and humanitarian operations).
- Emphasis on maneuver flexibility and avoidance of the adversary's established defenses/obstacles.
- Using a cross-domain approach by treating the littorals collectively as one operating domain.
- Using dispersed forces to avoid negative adversary effects.
- Employ scalable landing forces.
- Increase options for partnering with other general purpose forces and other government agencies.
- Gain local area control for required periods of time in order to accomplish the mission.

A wide variety of amphibious assets and platforms are necessary to conduct STOM operations and perform littoral maneuver. Aircraft, such as tilt-rotor and heavy-lift rotor, are a part of the vertical maneuver force that provides longer range/over-the-horizon landing capabilities of troops and light-weight equipment with excellent speed for a faster operational tempo. Landing craft, such as LCACs and LCUs, are a part of the surface maneuver force that provide the heavy lift capabilities that bring large quantities of supplies and troops over-the-horizon to the beach. The rapid movement of troops inland directly to the objective areas will also create an overwhelming fast operational tempo that will outpace the adversary's ability to react, be it an enemy force or Mother Nature. The various landing craft also provide a means to seamlessly maneuver over both the sea and land portions of the littorals. Each gives the amphibious force a multitude of ways to reach the mission objectives with a scalable amount of combat power and aggressiveness (*Ship-to-Objective Maneuver* 8, 21–22).

Using both of the vertical and surface force capabilities simultaneously is what makes STOM a unique tactic and technique to use in the wide spectrum of operations. Amphibious assault ships, such as the LHA, are the central hub of the STOM mission, as they provide the launch, recovery, and maintenance platform for both the landing craft and aircraft. Other important mission assets that the big deck amphibious assault ships bring to the fight are Command, Control, Communications, Computers, and Intelligence (C4I) systems, logistical support; messing and berthing; full medical facilities; unit and staff accommodations; and offensive and defensive weapons suites (*Ship-to-Objective Maneuver* 8, 21–22). As seen with OMFTS, the *America* class LHAs will also have a serious disadvantage with STOM since it uses both vertical and surface forces to accomplish missions. *America* class LHAs will be limited to providing vertical forces only. The new amphibious platform also lacks a full medical facility, as it was reduced by half to accommodate larger hangar bay space for aircraft maintenance on the MV-22 *Osprey* and F-35 Joint Strike Fighter ("LHA 6 Information" 5).

3. OMFTS and STOM Concepts Combined

The OMFTS and STOM guiding principles in amphibious warfare are what Sailors and Marines have trained to and performed over the last several decades. These concepts along with a powerful amphibious fleet are the reasons why the United States has the most capable amphibious force in the world. In order to demonstrate the importance of the well deck and to show that the OMFTS and STOM principles are centered on the dual well deck – flight deck capability in amphibious operations, both doctrinal concepts were combined and analyzed. Since STOM is the tactical implementation of OMFTS, the STOM tenets were mapped back to the more general OMFTS principles in matrix form followed by a detailed analysis of each area:

- OMFTS focuses on an operational objective.
- STOM: Focus equally on soft and hard power missions (from combating hostile engagements to Noncombatant Evacuation Operations, NEO, and humanitarian operations).
- STOM: Gain local area control for required periods of time in order to accomplish the mission.

The OMFTS principle of "focusing on an operational objective" is very generic as most missions will seek to achieve specific goals and purposes. Accomplishing both soft and hard powered combat missions along with NEO and humanitarian operations can be achieved without a well deck capability, but with how much ease and at what cost. As stated previously and proven by the mission types of LHAs and LHDs from 1979 to 2006 data, amphibious ships have been given a great deal of combat and humanitarian tasks and missions repeatedly because of the versatile assets this force has. The well deck asset is heavily relied upon to accomplish these missions. Without it the mission may be achieved, but at greater costs to the troops and the effectiveness of the operation. Much the same can be stated about the time required to gain local area control to accomplish the mission. It may be able to be achieved without a well deck capability, but again at what cost to the landing force.

- OMFTS uses the sea as maneuver space.
- STOM: Conduct littoral maneuver while using the sea as a protective barrier and highway for logistics and to outflank the enemy.
- STOM: Emphasis on maneuver flexibility and avoidance of the adversary's established defenses/obstacles.

The OMFTS principle of "using the sea as a maneuver space" is once again vague and states the obvious. The Navy and Marine Corps are well accustomed to operating and maneuvering on the sea, especially in the littorals. Using the sea as a protective barrier, a highway for logistics, and as a means to outflank the enemy clearly indicates the need for amphibious landing craft. Aircraft are essential in amphibious operations; however, it is using the sea as a maneuver space that is emphasized here. The requirement of landing craft in this principle means that a well deck capability is also a necessity. The various amphibious landing craft provide the transportation of equipment, supplies, and vehicles along the logistical sea highway and provide a flexible means to maneuver troops to outflank the enemy and avoid established defenses and obstacles. In conjunction with landing craft, aircraft will also be able to achieve these concepts. Without a well deck capability, the amphibious force is limited to air assets only which would result in a decrease in both troop flexibility and ability to maneuver to avoid the enemy, especially if the adversary has surface-to-air missiles. Therefore, this OMFTS principle and these STOM tenets rely heavily on the dual amphibious landing craft and aircraft capability. Not having a well deck would defeat the whole purpose of the OMFTS and STOM concepts.

- OMFTS generates overwhelming tempo and momentum.
- STOM: Use of seabasing to limit the footprint ashore and diminish the operational pause following troop landing.

Generating overwhelming tempo and momentum to keep constant pressure on the enemy is essential in defeating any adversary. By limiting the logistical footprint ashore, friendly forces limit the exposure of a critical vulnerability to the adversary to disrupt, destroy, or exploit. Diminishing the operational pause following troop landing will keep the pressure on the enemy and not allow them to regroup or reorganize. It will also add to increasing the operational tempo and prevent a shift in momentum towards the enemy. The need for a well deck capability is crucial to this principle because without it will limit how troops and equipment get to shore. A one sided air assault is not flexible and can be predictable. Plus it will cause the undesired operational pause, defeating the entire purpose of these two doctrines. Air assets do not have the ability to simultaneously land combat ready Marines and heavy equipment due to lift and weight constraints. Well decks allow for landing craft to bring heavy equipment, supplies, and vehicles ashore while helicopters fly personnel to the beach all at the same time. This cannot be done with just air assets.

- OMFTS pits strengths against weakness.
- STOM: Emphasis on maneuver flexibility and avoidance of the adversary's established defenses/obstacles.
- STOM: Employ scalable landing forces.

Pitting strengths against the enemy's weaknesses is typically what is expected when fighting against an adversary. Of course friendly forces want to put their strength against the enemy’s weakness in order to defeat them with as little damage or death as possible to their own force. Avoiding enemy defenses and obstacles relates to pitting strengths against weakness since amphibious forces want to steer clear of enemy strongholds and maneuver troops to areas that are weaker in order to break down and defeat the enemy. Employing a scalable landing force adds strength as more troops allows for overpowering the adversary. The need for a well deck once again arises as landing craft are required to land the landing force and aid in maneuvering forces to avoid enemy defenses. The dual air and sea attack on an enemy force adds to the strength of the most capable and powerful amphibious force in the world. Not having a well deck in the picture will compel the Navy and Marine Corps to change how they will pit their strengths against the weaknesses of the enemy. Conducting amphibious operations only with an air asset capability violates time proven amphibious tactics, techniques, procedures, and doctrine that the Navy and Marine Corps uses, trains to, and how they think and plan for missions.

- OMFTS emphasizes intelligences, deceptions, and flexibility.
- STOM: Improve options for the Joint Force Commander by having a readily available force at all times within the operating area.
- STOM: Using dispersed forces to avoid negative adversary effects.

Intelligence gathering, deceptions, and flexibility are incorporated into any type of military operation. Flexibility is the greatest element that the Joint Force Commander can be given as amphibious ships provide a variety of assets and means to maneuver troops and equipment ashore within the operating area. One of the best ways to occupy or distract the enemy is to position a rather large amphibious landing force off their coast, whether it is to gather intelligence, see how the enemy reacts, or as a means to deceive, as seen in Operation Desert Storm. Either way it gives the Joint Force Commander the option to use the available force for whatever he or she sees fit. The amphibious force can also provide the Joint Force Commander with additional flexibility to react to any sudden enemy movements by employing a large, scalable landing force or dispersing the troops to avoid any negative adversarial effects. To do this, a well deck capability is required. Amphibious assault ships are flexible because they can perform both aircraft and landing craft operations. It allows for the Joint Force Commander to employ the troops in multiple fashions. Amphibious warfare brings many assets and many capabilities to the warfighting table. If a major capability, i.e. the well deck, is taken away, then it only limits the Joint Force Commander and landing forces' ability to conduct operations and accomplish the mission.

- OMFTS integrates all organic, joint, and combined assets.
- STOM: Application of the single-battle concept and treatment of the battlespace as an indivisible entity.
- STOM: Improve options for the Joint Force Commander by having a readily available force at all times within the operating area.
- STOM: Using a cross-domain approach by treating the littorals collectively as one operating domain.
- STOM: Increase options for partnering with other general purpose forces and other government agencies.

Integrating all types of assets is the name of the game in amphibious warfare. The Navy and Marine Corps join together with the Army and Air Force in one, indivisible battlespace to allow the Joint Force Commander the ability to conduct joint operations with a valuable set of assets. The theme in each of these four STOM tenets is operating jointly in a single battlespace domain. The single battlespace domain happens to be the littorals which signal the need for an amphibious landing force and of course a well deck capability. Combining the simultaneous use of the well deck and flight deck assets is what makes the United States amphibious capability the most dominate and unique in the world. If the well deck asset is taken away, it makes achieving the mission objectives a much more difficult task.

The OMFTS and STOM principles and concepts are centered on the Navy and Marine Corps' ability to conduct landing craft and aircraft operations on board amphibious assault ships. Eliminating the well deck will negatively impact how the Navy and Marine Corps conduct amphibious operations and add significantly more challenges to landing troops ashore. As seen through this analysis of the OMFTS and STOM principles, the well deck capability is not only heavily relied upon to complete amphibious raids and assault, but to conduct humanitarian aid and disaster relief operations as well. If drastic changes are made to current Navy and Marine Corps amphibious capabilities, then the doctrine used to guide the planning and execution of operations and missions must be given a chance to address and reflect upon these limitations.

4. Joint Doctrine for Amphibious Operations (Joint Publication 3-02)

OMFTS and STOM may set forth the higher level principles for amphibious warfare, but it is Joint Publication 3-02 that provides the guiding principles for the military to conduct amphibious operations. As with most joint doctrine, general concepts and descriptions are outlined and discussed to establish a baseline of terminology for each of the armed services to commonly use and understand.

The concept of amphibious operations involves launching a landing force embarked on ships or craft by sea in order to accomplish assigned missions ashore. The five types of amphibious operations consist of demonstrations, raids, assaults, withdrawals, and other operations in permissive, uncertain, or hostile environments. An amphibious demonstration is a show of force meant to deceive the enemy in order to try and force them into an unfavorable course of action (*Joint Doctrine for Amphibious Operations* I-2). The different between an amphibious raid and assault is that a raid is a quick incursion or temporary occupation of an objective area followed by a planned withdrawal (*Joint Doctrine for Amphibious Operations* I-3). An assault is a lengthier process and involves the establishment of a landing force on a hostile shore in which they will occupy for a greater amount of time than a raid. An amphibious withdrawal is "the extraction of forces by sea in ships or craft from a hostile or potentially hostile shore (*Joint Doctrine for Amphibious Operations* I-2)." Other amphibious operations involve humanitarian aid and disaster relief, noncombatant evacuation operations, and various other military operations other than war (*Joint Doctrine for Amphibious Operations* I-3). The two forces that combine to accomplish these operations are the amphibious task force (ATF) and the landing force (LF). The ATF is the naval component formed to conduct amphibious operations and is commanded by a senior Navy officer (Commander Amphibious Task Force, CATF). The LF is the Marine Corps or Army component of the amphibious operation and is commanded by a senior Marine or Army officer

(Commander Landing Force, CLF). Each force will be the supported and supporting component during different phases of the operation (*Joint Doctrine for Amphibious Operations* I-1). The supported commander receives assistance from another commander's force or capabilities and is responsible for ensuring that the supporting commander comprehends the assistance required (*Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* 327). The supporting commander aids, protects, complements, or sustains another commander's force and is responsible for providing assistance required by the supported commander (*Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* 328). For example, during amphibious assault operations, the captain of the ship is the supporting commander while the Marine Expeditionary Unit (MEU) colonel is the supported commander. The captain and crew of the LHA or LHD will provide assistance and support while the Marines are offloaded ashore. The roles become reversed during operations and missions out to sea as the MEU colonel supports the captain of the ship, supplying extra defensive capabilities and personnel.

The underlying theme in amphibious operations continues to be the application of expeditionary maneuver principles, which are similarly described in the OMFTS and STOM doctrine. The goal of maneuver is to match strength against the enemy's weakness by using overwhelming speed and power to gain a temporal advantage. The most important capability, however, is having the means to conduct amphibious operations from over the horizon beyond visual sight of the coastline in order to conceal the force and extend them away from enemy line of fire and radar range (*Joint Doctrine for Amphibious Operations* I-6). Amphibious operations are an effective tool for the Joint Force Commander (JFC) to utilize because they exploit the adversary's weaknesses and apply a constant amount of combat power to accomplish the mission promptly by achieving campaign objectives in one swift stroke (*Joint Doctrine for Amphibious Operations* I-1, I-3). Amphibious forces also provide rapid deployable, adaptable, and versatile war-fighting capabilities to the JFC as they can accomplish such a wide variety of missions in all various types of weather and emission control (EMCON) environments. EMCON is the selective and controlled use of electromagnetic and/or acoustic emitters to optimize command and control capabilities while minimizing detection by enemy sensors and avoiding friendly interference (*Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* 328).

Amphibious operations require a flexible command and control system in order for the appropriate commanders to make quick decisions to maintain a high tempo of operations. Command and control is "the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission" (*Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* 61). The C4I systems and equipment must support this type of command and control structure and all its functional areas, which include fires, aviation, intelligence, combat service support, etc. (*Joint Doctrine for Amphibious Operations* VI-1). A C4I Systems Support Plan is prepared in detail that depicts all aspects of communications circuits and channels, radio and weapons guidance, call signs, frequencies, cryptographic and authentication systems, and policies and procedures to govern the operation and coordination of the overall system (*Joint Doctrine for Amphibious Operations* VI-4). The following is a list of the eight basic items a C4I Support Plan requires (*Joint Doctrine for Amphibious Operations* VI-5):

- General coverage of the communications situation and the concept of operation communications employment.
- Announcement of the communications mission.
- Delegation of tasks and responsibilities to major elements of the force.
- Detailed instructions for organization, installation, operation, coordination, and maintenance of the communications system.
- Assignment and employment of call signs, frequencies, cryptographic aids, and authentication systems.
- Instructions on countermeasures, operations security, military deception, and communications security.
- Interoperability of all required communications systems.
- Logistic support for communications and electronics.

Another important aspect of the command and control system of amphibious operations is the five planning phases: Planning, Embarkation, Rehearsal, Movement, and

Action. Planning begins when a warning or operation order is given to the task force and notionally ends at the start of the embarkation phase. Planning is, however, continuous throughout the operation but changes hands between the amphibious force commanders as the operational phase begins. During the Embarkation phase, the landing force along with its equipment, vehicles and supplies embark on various amphibious assault ships. A great deal of flexibility and ingenuity is involved in this phase to account for any changes to the original plan that may require reconfiguring the embarked forces. The Rehearsal phase is the period in which the landing force tests the adequacy and feasibility of the plan by either performing an actual landing and/or conducting a command post exercise. Rehearsing the plan allows all echelons involved to become familiar with the flow of operations and provides an opportunity to reconfigure forces if necessary. During the Movement phase, the amphibious forces deploy from the port of embarkation to the forward operating area. This phase is completed when all elements of the amphibious force arrive at their assigned positions in the operational area. The Action phase is the decisive amphibious landing of troops, supplies, and equipment from the ships to the beach and other objective areas and terminates following the accomplishment of the mission (*Joint Doctrine for Amphibious Operations* I-7).

5. National Security Strategy and National Military Strategy

The National Security and Military Strategies set forth guidance and vision for the United States Armed Forces and allude to the focus of future operations and missions. The current strategic American interests include the security of the United States, its citizens and allies, a strong economy that promotes opportunity and prosperity, respect for values all over the world, and an international order that promotes peace and security through cooperation to meet global challenges (*National Security Strategy* 7). From a military perspective, keeping the United States and the American people safe and secure begins with a strong defense at home and abroad. It is therefore necessary and essential that the Armed Forces have a substantial amount of leadership, training, and equipment required to accomplish the mission (*National Security Strategy* 22) and not limit or cut any critical capabilities that the services rely on to fight.

A key theme in both the National Security and Military Strategies is to "prepare for increasingly sophisticated adversaries, deterring and defeating aggression in anti-access environments" (Work 6). Anti-access environments, in a Navy and Marine Corps sense, are those areas in the littorals in which the only way in is by forceful entrance by sea. Winning the access battle as new challenges emerge is vital to the U.S. foreign policy, alliances, and global interests to project power and promote worldwide security (Work 7–8). This is exactly why the United States Navy and Marine Corps retains an amphibious assault capability. Gaining access to areas of interest, particularly in the littorals, is precisely what an amphibious force can achieve.

Established from the National Security Strategy, the National Military Objectives include countering violent extremism, deterring and defeating aggression, strengthening international and regional security, and shaping the future force (*The National Military Strategy of the United States of America* 4). The Navy and Marine Corps team plays a role in each of these objectives, especially in projection of power as they are the most mobile and flexible force in the world. While unconventional warfare has become more common over the past decade, maintenance of a robust conventional deterrent is required to discourage the enemy and defeat aggression. Deterrence also "requires the ability to rapidly and globally project power in all domains," which the Navy and Marine Corps excel in, train to, and practice through proven doctrinal concepts (*The National Military Strategy of the United States of America* 8). Preserving the forward presence of the U.S. along with safeguarding access to bases, ports, and airfields around the world adds to strengthening international and regional security (*The National Military Strategy of the United States of America* 10). Humanitarian aid and assistance operations also fit into this objective, especially after natural disasters where chaos and insecurity can ensue. As mentioned earlier, because of their versatility and available resources, amphibious assault ships and forces have successfully taken on an increased roll of humanitarian operations as they are able to reach inaccessible areas. Shaping the future maritime force involves a mix of both small and large multi-mission capable platforms that provide the ability to conduct the full range of naval operations across all domains (*The National Military*

Strategy of the United States of America 19). Amphibious assault ships fit this profile as they are the larger units that can perform a multitude of missions globally through all operational environments.

C. CURRENT LHA LIFT CAPABILITIES AND CONFIGURATIONS

In conjunction with the establishment of written doctrine and key concepts, the second major component in the development of amphibious warfare tactics was the construction of specialized warships. The first ship designed from the keel up to support amphibious operations was the Amphibious Assault Ship (Helicopter), or LPH class, in the 1950s ("LPH-2 IWO JIMA Class: Overview"). The LHA *Tarawa* class ships followed in the 1970s and the LHD *Wasp* class in the 1980s as the first amphibious assault ships with a well deck. For the purpose of this thesis, the lift capabilities and configurations of the *Tarawa* class LHAs will be explored in detail in order to compare it with the replacement *America* class LHAs of the future.

1. LHA *Tarawa* Class

The *Tarawa* class LHAs were constructed by Ingalls Shipbuilding in Pascagoula, Mississippi starting in the late 1970s. The maximum speed of LHAs is 24 knots with a maximum range of 10,000 nautical miles at a more sustainable 20 knots ("LHA-1 Tarawa Class"). *Tarawa* class LHAs have a crew of about 1,000 naval personnel and have the ability to embark roughly 2,000 Marines ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

The *Tarawa* class LHAs were designed and built for both fixed and rotary wing aircraft operations along with simultaneous wet well deck operations. The maximum aircraft configuration on the LHA is as follows: 12 CH-46 *Sea Knight* helicopters, four CH-53E *Sea Stallion* helicopters, three UH-1N *Huey* helicopters, four AH-1W *Super Cobra* helicopters, and six AV-8B *Harrier* attack aircraft ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). While this is the typical aviation load-out for a *Tarawa* class LHA, number and type of aircraft will vary depending on the mission and tasking for the particular Expeditionary Strike Group (ESG)/Amphibious Ready Group (ARG). This typical aviation load-out will also be used as the standard throughout this thesis.

The LHA well deck design allows for two typical configurations due to a divider down the center of the well: four LCUs (split two and two, one behind the other) or two LCUs and one LCAC (LCUs forward, one on either side of the divider with the LCAC at the stern). Figure 2 is an image of the *USS Tarawa's* well deck, showing the divider down the right side of the photo. AAVs can also be launched and recovered from the LHA, however, no other craft can be in the well deck at the same time ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). These landing craft configurations will be used as the standard throughout this thesis.

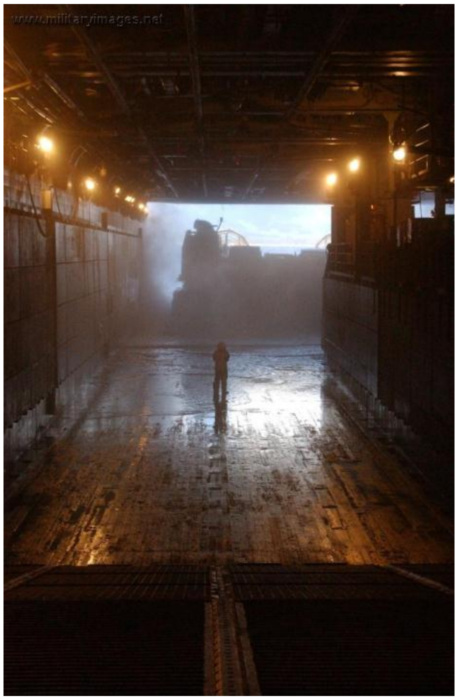

Figure 2. LHA Well Deck (From "LCAC departs the well deck of *USS Tarawa* [LHA 1]").

The five categories or footprints of amphibious lift are 1) the number of troops each ship can carry, 2) square footage of the vehicle storage area, 3) cubic footage of the cargo storage area, 4) the number of helicopter parking spots, and 5) the number of

LCAC landing spots (*A CBO Study: The Future of the Navy's Amphibious and Maritime Prepositioning Forces* 4). As mentioned earlier, LHAs can embark up to 2,000 Marines and have one LCAC spot in the well deck. The vehicle storage area of the LHA is 25,400 square feet while the cargo storage area is 105,900 cubic feet. The number of helicopter spots, expressed as CH-46 equivalents, is 42 (*A CBO Study: The Future of the Navy's Amphibious and Maritime Prepositioning Forces* 4).

2. Landing Craft Air Cushioned (LCAC)

LCACs are the high speed, over-the-horizon, ship-to shore transporter for Marines along with their equipment, weapons and cargo. Developed and built by Textron Marine and Land Systems, LCACs began their life cycle in the Navy in the early 1980s. LCACs can maintain a 40 to 50 knot speed over water with a full load and have a range of 200 nautical miles at 40 knots and 300 nautical miles at 35 knots with a payload ("United States Navy Fact File: Landing Craft, Air Cushioned").

The LCAC is a unique landing craft for the Navy and Marine Corps to use and operate as it can reach more than seventy percent of the world's coastline due to its air cushion technology that allows the craft to glide or fly across the water and beaches. This significantly increases the ability of the Marine Ground Combat Element to land on just about any beach in the world ("United States Navy Fact File: Landing Craft, Air Cushioned"). LCACs are capable of carrying up to 60 to 75 tons, including all vehicles in a Marine Expeditionary Brigade (MEB), large equipment containers, rough terrain cargo handlers, and any palletized loads (DuBose). Examples of MEB equipment, weapons and supplies include M1A1 tanks, 155mm Howitzers, 81 and 60mm Mortars, anti-tank missile launchers, Javelins, 50-caliber machine guns, stinger missiles, HMMWVs, light armored vehicles, 7-ton trucks, dump trucks, logistics vehicle systems, refuelers, dozers, and cranes ("United States Marine Corps"). The LCAC can also be used to transport troops ashore in either cabin seating, totally 24 available seats, or by a marine carrier transport, which seats 150 troops ("Landing Craft, Air Cushioned – LCAC). The cargo deck area is 1,809 square feet and is 27 feet wide. The bow ramp is also 27 feet wide while the stern ramp is narrower at 15 feet (DuBose). The limits to LCACs are therefore weight and area along with sea state, as they cannot operate in a sea state greater than three.

3. Landing Craft Utility (LCU)

Like LCACs, LCUs are used by amphibious forces to transport Marines and their equipment, weapons, and supplies ashore. While a much older design dating back to World War II, LCUs still remain as the backbone of heavy amphibious lifts. The three current active classes in the Navy, LCU 1610, 1627 and 1646, were built throughout the 1970s by various shipbuilders in the United States. LCUs have the ability to carry a heavier load than LCACs; however, the trade-off for carrying capacity is speed as the LCU can only reach a maximum of 11 knots. LCUs have a range of 1,200 nautical miles at a sustained eight knots and have the ability to operate out to sea for up to ten days ("United States Navy Fact File: Landing Craft, Mechanized and Utility (LCM/LCU)").

LCUs have both a bow and stern ramp, similar to the LCAC, for on-load and off-load of the various equipment, vehicles, weapons, and supplies from ship to shore. The cargo deck area measures 1,785 square feet and each ramp is the same width of the LCU, 29 feet ("Landing Craft Utility (LCU)"). The maximum lift LCUs can carry is up to 170 tons or over twice what LCACs can carry. LCUs can also carry all vehicles in the MEB, including three M1A1 tanks and ten light armored vehicles at once, transport 400 plus troops, or 125 tons of cargo. As with LCACs, LCUs can have a variety of load configurations due to the various amounts of equipment and vehicles and nature of the mission. The limitations of LCUs are the same as LCACs, but also have a disadvantage when it comes to speed. Like the LCAC, LCUs cannot operate in a sea state greater than three ("United States Navy Fact File: Landing Craft, Mechanized and Utility (LCM/LCU)").

4. Amphibious Assault Vehicles (AAV)

AAVs are armored assault full-tracked landing vehicles that carry Marines and cargo ashore during amphibious operations ("AAV-7 Amphibious Assault Vehicle").

Designed and manufactured by the FMC Corporation in the early 1970s, AAVs sustain the primary means of armored protected mobility for the Marine Ground Combat Element. It remains in service as the unique sea and land personnel carrier with the capability to land troops ashore in hostile environments (“PM AAVS Program Brief” 3). AAVs have a cruising speed through the water of five knots with a maximum speed of seven knots. The range of the AAV in the water is seven hours at five knots and on land is 300 miles at 21 knots (“LVTP7 Landing Vehicle, Tracked AAVP7A1 Assault Amphibian Vehicle Personnel”).

The primary mission of AAVs is to spearhead the beach during an amphibious assault. Once disembarked from the ship, AAVs go ashore carrying infantry and supplies to provide a forced entry into the amphibious assault area and establish a position for the surface assault echelon (“LVTP7 Landing Vehicle, Tracked AAVP7A1 Assault Amphibian Vehicle Personnel”). AAVs can carry up to 21 combat-equipped Marines or 10,000 pounds of cargo (“AAV-7 Amphibious Assault Vehicle”). These two typical configurations will be used as the AAV standard throughout this thesis. The limits of AAVs are again similar to LCACs and LCUs, but are more restrictive when it comes to speed, sea state, and distance to land. AAVs are much slower through the water, require closer launches to land, and cannot operate in sea states greater than two.

D. CHAPTER SUMMARY

This chapter introduced amphibious assault ships, their history, doctrine, and current configurations that are being utilized by the Navy and Marine Corps. The Pacific theater in World War II had a major influence of how today’s U.S. amphibious operations are planned and executed. The development and design of ships, landing craft, and aircraft over the past several decades have been tailored to the doctrine and training of the Navy and Marine Corps. Maintaining a complex, two-tiered amphibious assault capability has proven crucial as LHA and LHD ESG/ARGs are continually tasked with a variety of missions. The future of the amphibious fleet and a shift in design will be examined in the next chapter.

The LHA *Tarawa* class model will be used throughout this thesis. However, the LHD *Wasp* class model may be substituted and used subsequently with minor changes to the configuration and lift capabilities. Both the current LHA and LHD classes have the ability to carry LCACs, LCUs and AAVs along with all aircraft from the Marine Air Combat Element.

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III. CHANGE IN SHIPBOARD AMPHIBIOUS DESIGN

A. OVERVIEW

The current LHA amphibious design model centers on the Navy and Marine Corps' ability to conduct landing operations by sea and air. LHA *Tarawa* class amphibious ships can conduct landing craft and aircraft operations simultaneously, allowing for a two-pronged approach in the desired amphibious objective area. The future LHA (R) design model will dramatically shift how amphibious operations are conducted. With the elimination of the well deck in the *America* class amphibious ships, this new design will focus solely on aviation assets to land Marines ashore.

This chapter will look at the new amphibious assault ship design and describe its expected capabilities and load configurations. It will discuss the design decision process and how it was applied to creating this new LHA (R) amphibious model. Lastly, this chapter will look at previous design models in order to determine best practices and lessons learned with regards to developing a suitable recommended model for the Navy and Marine Corps to utilize.

1. LHA (R) *America* Class Layout and Design

The first of the three ships procured in the LHA (R) *America* class is currently being constructed in Pascagoula, Mississippi by Northrop Grumman Ship Systems ("PEO Ships Amphibious Assault Ships (LHA 6): Program Summary"). The *Pre-Commissioned Unit (PCU) America*, LHA 6, is scheduled for delivery to the U.S. fleet in 2013 with a 2014 commissioning date. Modeled after the *USS Makin Island* LHD 8 design, the LHA (R) *America* class will also be a gas turbine-electric ship ("United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)"). The maximum speed of the new LHA will be 22 knots with an expected maximum range similar to the *Tarawa* class at 10,000 nautical miles. The crew will consist of 1,204 personnel with the ability to embark up to 1,871 landing force troops. The remaining amphibious lift footprints will be as follows: the vehicle stowage area is 10,328 square feet; the cargo stowage area is 160,000 cubic feet; number of helicopter spots expressed as CH-46 equivalents is 45; and number of LCAC spots is zero ("LHA 6 Information" 4–6).

The *America* class cannot support any landing craft (LCACs, LCUs, and AAVs) due to the elimination of the well deck and therefore does not have a surface load configuration. Like that of the *Tarawa* class, *America* class amphibious ships will have the ability to conduct both rotary and fixed wing aircraft operations, primarily flying the MV-22 *Osprey* and F-35 Joint Strike Fighter. The CH-53E *Sea Stallion*, UH-1Y *Huey*, AH-1Z *Super Cobra*, and MH-60S helicopters will also be able to embark onboard; however, will be limited due to the focus on the newer *Osprey* and Joint Strike Fighter aircraft. The two typical planned aviation load-out configurations for the LHA (R) will be a Combined Load for maximum use of the *Osprey* and Joint Strike Fighter and a Notional Marine Expeditionary Unit (MEU) Mix. The Combined Load will consist of 12 MV-22 *Ospreys*, 12 F-35 Joint Strike Fighters, and two MH-60Ss for search and rescue. The Notional MEU Mix will consist of 12 MV-22 *Ospreys*, six F-35 Joint Strike Fighters, seven AH-1/UH-1 *Huey* and *Super Cobras* mixed, four CH-53E *Sea Stallions*, and two MH-60Ss for search and rescue ("LHA 6 Information" 4). As with the *Tarawa* class, these are the typical aviation load-outs for the *America* class and are subject to change depending on the mission and tasking assigned. These two load-outs will be used as the standard throughout this thesis.

The biggest design difference between the *Tarawa* and *America* classes is the decision to eliminate the well deck to provide additional space for supporting aviation elements. The extra area gained went to extending the hangar bay in length and added several feet in height in order to support maintenance and service to the MV-22 *Osprey* ("USS America (LHA 6): A Different Kind of Gator"). Ballast tanks, used to flood the well deck, were converted to carry extra jet propulsion fuel, JP-5, thereby increasing the amount of aviation fuel to 1.3 million gallons. The remaining space allowed for more aviation storage and maintenance shops to support embarked aircraft. Medical facilities were also reduced down from four to two operating rooms and from 48 to 24 hospital ward beds to support the need for more aviation required space ("LHA 6 Information" 4–6).

2. MV-22 *Osprey*

The MV-22 *Osprey* is the Marine Corps' version of this tilt-rotor aircraft that combines the speed and range of an airplane with that of the vertical flight capabilities of a helicopter ("MV-22 Osprey: Speed, Range and Vertical Flight"). The *Osprey* was designed for expeditionary assault, raid operations and cargo lift ("MV-22 Osprey: Speed, Range and Vertical Flight") but can also perform other secondary missions which include search and rescue and special operations (Bolkcom Summary). The V-22 program began in the early 1980s by the Department of Defense and continued to grow throughout the 1990s and early 2000s as a joint service project with the Marine Corps as the lead service in the development of the aircraft (Bolkcom Summary and "United States Navy Fact File: V-22A Osprey tilt rotor aircraft"). While the program remains in a somewhat controversial stage due to issues surrounding testing accidents, maintenance, and cost, the *Osprey* is still scheduled to become the Marine Corps' aircraft of the future (Bolkcom CRS-2). Currently, the Marine Corps is planning to purchase 360 *Ospreys* while the Navy is scheduled to buy 48 over the next decade ("United States Navy Fact File: V-22A Osprey tilt rotor aircraft").

Built by Bell-Boeing, the MV-22 performs vertical take-offs and landings with the rotor blades in the upright position, similar to that of a normal helicopter. Once stable in the air, the blades rotate down like a jet propeller plane, having a maximum cruising speed of 241 to 257 knots depending on ceiling limitations. The range of the aircraft varies with mission and fuel capacity. The mission radius with the aft sponson fuel tank for land-assault troop missions is 242 nautical miles while for a pre-assault raid is 267 nautical miles. The mission radius with full wing fuel tanks for land-assault troop missions is 233 nautical miles while for a pre-assault raid is 306 nautical miles. Land-assault troop missions are performed during amphibious assaults in which the aircraft would be carrying the maximum capacity of 24 combat-ready Marines. Pre-assault raids occur prior to major amphibious operations to prepare the battle space, perform reconnaissance, and collect intelligence. The load in the aircraft is less during pre-assault raid operations and therefore has a greater range during those missions. Its single cargo hook can lift 10,000 pounds, or the equivalent of one Howitzer, and its dual hook can lift

15,000 pounds ("V22 Characteristics"). The expected maximum amount of MV-22 *Ospreys* to embark on board the LHA (R) class is 12 ("LHA 6 Information" 4).

3. F-35 Joint Strike Fighter

The F-35 Joint Strike Fighter (JSF) will be the next generation strike aircraft weapon system for the Navy, Marine Corps and Air Force, replacing the F/A-18 *Hornet*, AV-8B *Harrier*, and F/A-22 *Raptor* from each of the respective services ("Program Overview: Program"). The aircraft is currently being developed, tested, and produced in three different variants for each service by Lockheed Martin ("Introduction: F-35"). The Marine Corps' variant, F-35B, will have the short takeoff and vertical landing (STOVL) capability like that of the aging AV-8B *Harrier*. The STOVL capability is necessary in order to embark on board amphibious assault ships since they do not have a catapult or arrest wire system to launch and recover aircraft ("Background: F-35"). The Marine Corps intends to purchase 680 F-35Bs over the next ten years, however, the number may be reduced due to cost and decreased future Congressional funding (Gertler 7).

Like the MV-22 *Osprey*, the F-35 JSF will dominate the flight deck of the LHA (R) *America* class amphibious assault ships. The JSF will be larger and heavier than its *Harrier* predecessor with a length, height and wingspan of 51.2 feet, 14.3 feet, and 35 feet, respectively. The aircraft's weight empty is 15,000 pounds with a maximum weight of 60,000 pounds ("F-35B Short Takeoff/Vertical Landing Variant") compared to the Harrier's weight empty at 14,000 pounds and maximum weight of 31,000 pounds ("AV-8B Harrier: Overview"). The maximum speed of the JSF is 1.6 mach with combat radius listed as greater than 450 nautical miles and maximum range listed at greater than 900 nautical miles (actual numbers are classified). The weapons payload of the aircraft is 15,000 pounds with a standard load-out of two air to air missiles and two 1,000 pound guided bombs ("F-35B STOVL Variant: F-35 Lightning II."). Used only as a JSF platform, the LHA (R) will be able to carry a maximum of 22 aircraft on board ("LHA 6 Information" 4). Since this aircraft is purely a strike fighter, it does not have any lift capabilities and will be used only as a strike asset during amphibious assaults and raids. While the JSF will be a lethal and useful aircraft during amphibious operations, growing concerns have risen surrounding the lift phases of the campaign. As the number of F-35s on board the new LHAs increase, it reduces the amount of available helicopter lift assets necessary to support the off-load of Marines along with their equipment, supplies, cargo, and vehicles since there is not a landing craft capability to perform this function. This issue will be explored further in Chapter IV.

B. DESIGN DECISIONS

The process to determine the best design models for the U.S. military is quite complex and involves a number of different parties with competing interests. The Department of Defense (DoD) has adopted an acquisition policy that steps through each phase of the complex process to develop the military's needs and wants into physical capabilities. It is in this acquisitions process where design decisions are made and then turned into reality with the construction of the project. The intent of the acquisition process is to pursue solutions for gaps in military capabilities based on requirements and performance. All too often, however, politics, money, and personal agendas get in the way of this process and can cause it to run astray from its intended purpose.

While the DoD's acquisition policy sets forth specific guidelines and requirements to follow, it is an overall generic scheme that can be tailored to each specific project and program. For example, ship design and development in general follows a very different timeline than an aircraft would because it is a single, major construction project and not one of mass production. In order to determine the nature of the design decisions made with the *America* class LHAs, the acquisitions process will be examined and compared to how it was applied to the development of the new class of amphibious assault ships.

1. The Acquisition Life Cycle

The acquisition management system, or acquisition life cycle as it is commonly referred to in the DoD, is a generic model for obtaining defense systems. As seen in Figure 3, the life-cycle process has several phases that are separated by milestones, or decision points (Brown 41). Each project has a program manager who is responsible for accomplishing objectives for the development, production, and sustainment to meet the user's operational needs in defense acquisition (Brown B-147). The program manager uses the milestones and decision points in the life cycle as a framework with which to review his/her specific program, monitor and administer progress, identify potential problems early, and make any necessary corrections (Brown 41–42). The program manager reports to the milestone decision authority who is a designated individual that has overall responsibility for the program and has the authority to approve entry of the program into the next phase of the acquisition process. The milestone decision authority is also held accountable for cost, schedule, and performance reporting to Congress (Rendon and Snider 10–13).

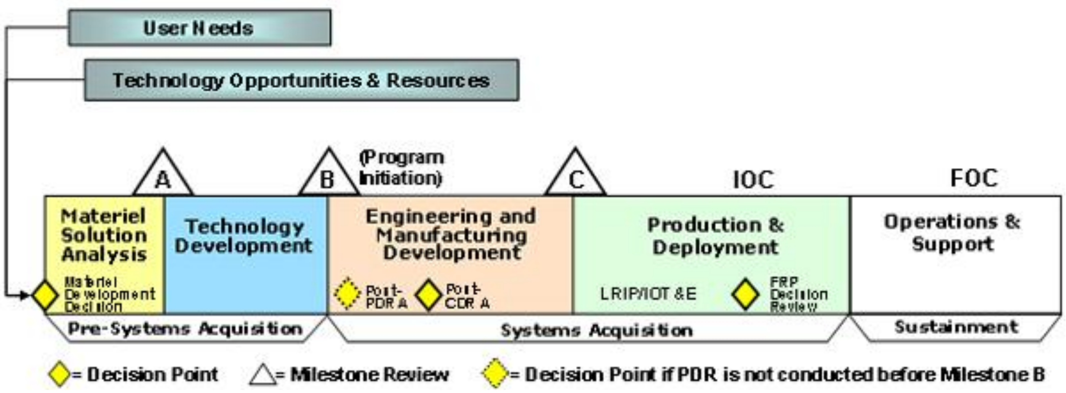

Figure 3. Defense Acquisition Management System (From "Enclosure 2–1. Defense Acquisition Management System").

The acquisition life cycle process begins when a military need exists and current capabilities are unable to satisfy the new condition. The Chairman of the Joint Chiefs of Staff (CJCS) and the Joint Requirements Oversight Council (JROC) together identify, assess, and prioritize joint military capabilities to accomplish missions (Brown 42). The JROC is chaired by the Vice Chairman of the Joint Chiefs of Staff and members include each vice chair of all of the armed services. The purpose of the JROC is to lead the Joint Staff in developing policies and procedures that determine and validate warfighting capability needs (Brown 30). The Joint Capabilities Integration and Development System (JCIDS) assist the CJCS and JROC in implementing the requirements process. The JCIDS process involves analyzing doctrine, organization, training, materiel, leadership, education, personnel, and facilities to define gaps in warfighting capabilities and propose solutions to close these gaps ("1.3. Joint Capabilities Integration and Development System (JCIDS)"). During this process, technological opportunities and resources are explored as well in DoD laboratories and research centers in order provide an initial assessment of the feasible technology that is available to solve the needs requirements ("1.3. Joint Capabilities Integration and Development System (JCIDS)").

Design decisions start to materialize following the JCIDS process as the program formally enters into the acquisition process beginning with the Materiel Solution Analysis Phase. During this phase a Materiel Development Decision is made when the Joint Staff presents the JROC's recommendations and the Initial Capabilities Document is completed (Brown 43–44). The Initial Capabilities Document presents the definition of the capabilities need and describes where it fits in the broader concepts and architectures (Brown 34–35). A key concept in this phase is the development of an analysis of alternatives study to develop feasible strategies that will meet the required needs listed in the Initial Capabilities Document. This analysis is important since it will determine which design route is chosen for the project to be manufactured (Brown 44).

Once the analysis of alternatives is complete and the capability need is identified and certified to fulfill the needs set forth in the Initial Capabilities Document, the program comes to its first decision point, Milestone A. The milestone decision authority for the program formally approves the materiel solution and technology development strategy at Milestone A and develops a cost estimate and resource availability strategy. The Technology Development Phase begins after the Milestone A decision. The purpose of this phase is to reduce technology risk by determining a set of feasible technologies to be integrated into the system by completing a preliminary design (*Operation of the Defense Acquisition System* 16). After a preliminary design is completed, the decision to continue on and initiate the program is made at Milestone B. The milestone decision authority must confirm that the technology is mature enough for systems level development to begin, that funds are acquired in the budget to carry out the acquisition strategy, and receive congressional certification that the program has a high likelihood of accomplishing its intended mission (Brown 45).

The Engineering and Manufacturing Development Phase is what brings the design decisions of a program to life. During this phase the design of the system is fully developed in an affordable and executable manner. System engineers are guided by key performance parameters, or critical user requirements, to create and develop the technical activities associated with the project. Program goals for cost, schedule, and performance are generated that will describe the program over its life cycle. A series of designs and prototyping also occur during this phase to ensure the system meets approved requirements and that it has the ability to be reproduced (*Operation of the Defense Acquisition System* 19–21).

At Milestone C, the milestone decision authority will make the decision to commit the DoD to production of the desired system. The Production and Deployment Phase marks the start of construction of the system to achieve operational capability and satisfy mission needs. The system will be produced, operationally tested, and then turned over to the appropriate service for use and deployment (Brown 47). The last phase of the acquisition life cycle is sustainment of the system in which full operational capability is achieved and logistical support is maintained. The life cycle ends with the final disposal of the system once its lifespan ends (Brown 48).

2. U.S. Navy Ship Acquisition Process

The Defense Acquisition Management System is a generic process used for the acquirement of various defense systems. The U.S. Navy, through the Naval Sea Systems Command (NAVSEA), has tailored this process towards shipbuilding and design. NAVSEA is the Navy's largest system command that engineers, builds, buys, and maintains ships, submarines, and combat systems in order to meet the current and future operational requirements of the fleet ("About NAVSEA"). While the general process remains the same, the shipbuilding acquisition life cycle has several specific deviations throughout the course of each program.

The shipbuilding acquisition life cycle starts out the same with the generation of needs and capabilities requirements through the JCIDS process. An analysis of alternatives and feasibility studies are still conducted during the Materiel Solution

Analysis Phase prior to the Milestone A decision. It is at Milestone A where the shipbuilding process changes as program initiation is approved here instead of at Milestone B. The Technology Development Phase is centered on the creation of the ship design and is the vital step in the process where design decisions are made. Figure 4 depicts the shipbuilding acquisition strategy through Milestone A. Designs are either modified and repeated or are redesigned new. The type of design will determine how contracts will be awarded; either competitive among companies or sole source ownership ("Surface Ship Design" 3).

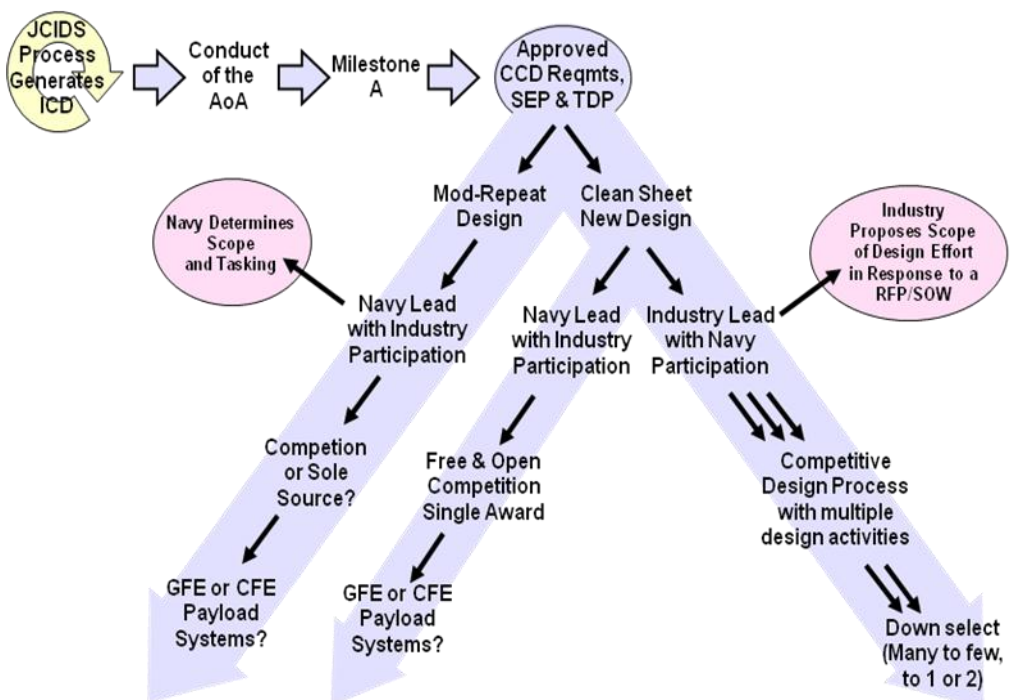

Figure 4. Shipbuilding Acquisition Strategy (From "Surface Ship Design" 4).

Between Milestones A and B, there are three distinct design phases: 1) Concept Design, 2) Preliminary Design, and 3) Contract Design. During the Concept Design Phase, industry teams develop a ship concept that responds to the Initial Capabilities Document requirements and offer trade-offs of major military requirements against ship size and cost. The Navy will simultaneously assess for technical feasibility and identify major risks for the proposed concepts. The Concept Design Phase will typically last from three to twelve months ("Surface Ship Design" 14). The purpose of the Preliminary

Design Phase is to fully define the ship characteristics and cost in a functional baseline for the ship alternative that was selected. The requirements flow-down process begins during this phase as the industry develops a Functional Baseline Design that conforms to the required standards. The major components of the ship are selected, including the hull form and new enabling technologies. The roles of the Navy during this phase are to review and approve the industry's Functional Baseline Design before moving on to more detailed plans. The Preliminary Design Phase will typically last from 12 to 15 months ("Surface Ship Design" 15). During the Contract Design Phase, the ship design is further developed and optimized to support the ship procurement package and refined cost estimate. The industry conducts performance and further detailed-oriented trade-off studies while developing an Allocated Baseline Design, in which the Navy must approve before a Milestone B decision is made ("Surface Ship Design" 16). The Allocated Baseline Design depicts the configuration items that make up the ship and how each is intended to function all together ("Establishment of Configuration Baselines"). The Contract Design Phase will typically last from 15 to 24 months ("Surface Ship Design" 16).

Following the approval of Milestone B, where the lead ship of the class will be approved and named, the Detail Design and Construction Phase will began. The purpose of this phase is to fully articulate the design in terms of product models, purchase specifications, construction drawing, and process instructions. The industry conducts a final detail design review in parallel with procurement of materials and components. Construction begins on the ship, which is surveyed throughout this phase by the Navy ("Surface Ship Design" 17). The Detail Design and Construction Phase will typically last for several years, depending on the size and technical aspects of the ship.

Another deviation from the original DoD acquisition process seen in shipbuilding is the absence of Milestone C. Once construction is complete, the ship is christened and launched into the water for the first time. Sea trials are then conducted to test and demonstrate the satisfactory operation of all installed shipboard equipment and ensure the ship performs in accordance with its plans and specifications. Once all tests are complete and satisfy the Navy, the ship is officially delivered to the fleet and sailed away from the shipyard. This marks the start of the Operations and Support Phase of the ship's life cycle as construction ends and naval operations begin ("Shipbuilding 101: Milestones").

3. *America* Class LHA Development and Production

The LHA Replacement Program began its journey through the acquisition process much the same as any other program with a desired need. The *Tarawa* class LHAs began reaching the end of their life cycle in the early 2000s and the Navy needed a replacement amphibious assault ship to take their place on the high seas. With a capability need in mind, several studies were conducted by the Center for Naval Analyses, including a LHA Development of Options Study in 1999, Mission Area Analysis in 2000, and an Analysis of Alternatives that was completed in 2002 (Sullivan 16). It is interesting to note that the LHA (R) Milestone A was approved in July 2001 prior to the Analysis of Alternatives completion in 2002, which signified program initiation. This deviates from the notional shipbuilding process as these events usually occur in the reverse order ("Schedule for LHA 6 AMERICA CLASS"). While several of these documents are limited in their distribution, the Navy decided not to use any of the newly proposed designs for the replacement LHAs and instead went with a repeat modified design of the gas turbine-electric hybrid LHD 8 model.

Table 7 shows the schedule for LHA 6, the first ship in the LHA (R) class. Each milestone is listed with an objective and threshold date. The objective date is the optimal goal to begin each milestone while the threshold date is the last possible time to begin the milestone in order to finish the project on schedule. The Estimate/Actual date lists when the milestone actually began or when it will approximately start.

Table 7. LHA 6 Schedule (After "Schedule for LHA 6 AMERICA CLASS").

LHA 6 Milestone Schedule			
Milestones	**Objective**	**Threshold**	**Actual/Estimate**
LHA (R) Milestone A	July 2001	January 2002	July 2001
LHA 6 Start Contract Design	May 2005	November 2005	May 2005
Advance Procurement Contract	July 2005	January 2006	July 2005
LHA 6 Milestone B	January 2006	July 2006	January 2006
Contract Award	December 2006	June 2007	June 2007
Start Fabrication	November 2007	May 2008	January 2008
Float Off	August 2010	February 2011	May 2012
Ship Delivery	December 2011	June 2012	October 2013
Operational Evaluation Start	August 2012	February 2013	August 2014
Operational Evaluation Complete	September 2013	March 2014	December 2014
Initial Operational Capability	September 2013	March 2014	April 2015

The LHA (R) Program followed the notional shipbuilding schedule through the summer of 2006. Up to that point, the LHA 6 design had been finalized with a well deck still in the plans. LHA 6 experienced an unprecedented event as her final design was changed right before construction began on the project without any alteration to the acquisition schedule. Key personnel in the Navy and the Northrop Grumman contractors made an inauspicious decision to remove the well deck from the LHA 6 plans to favor the extra space required for the maintenance and support of the MV-22 *Osprey* and F-35 Joint Strike Fighter (Harrison).

This design decision violated the Mission Need Statement for the LHA (R) Program that was approved by the Chief of Naval Operations and JROC in early 2001. The Mission Need Statement is a document generated by the JCIDS process in order to set forth the required performance parameters the project must meet to accomplish its objective. A specific requirement in the Mission Need Statement for the LHA (R) Program was "through the execution of the Ship-to-Objective Maneuver the LHA (R) will enable the forcible entry, reconstitution, and redeployment of the U.S. Marine Corps warfighting assets through air and surface delivery (Reynolds 2).” It also listed that the replacement LHAs have a “floodable well deck sized for three LCACs or two LCUs (Reynolds 3).”

Why a major change in the design of the new LHA? There were several factors that went into skewing the acquisitions process for the LHA (R). The biggest issue, like most projects, was with overall cost and finding ways to save money. The Office of the Chief of Naval Operations argued for the removal of the well deck to save money and capitalize on the heavy investments made in the V-22 and F-35 Programs. In essence, the Navy wanted to push for a specific platform where the controversial *Osprey* and expensive Joint Strike Fighter could make a permanent home (Work 221–222). Another reason for the shift in design was to accommodate for aviation-centric missions in the Arabian Gulf operational environment. The argument was to focus on the development and deployment of aviation assets since the current war was being fought in Afghanistan, a place where landing craft could not roam (Sullivan 9). The impacts of these design decisions will be explored further in Chapter IV.

Nonetheless, the fate of LHA 6 was sealed as construction on the first amphibious assault ship without a well deck since the 1950s began in January 2008. Unexpected delays have pushed the LHA (R) Program further off track with an expected ship delivery date of the fall of 2013 instead of the summer of 2012 (“Schedule for LHA 6 AMERICA CLASS”). The delay in delivery of LHA 6 to the fleet has caused the Navy to extend the service life of the remaining older LHAs which are long past their expected decommissioning dates. This delay also causes setbacks to the Navy’s future shipbuilding plans as it will delay the fleet’s goal of reaching 33 amphibious ships by 2016 (Labs 21).

The LHA 6 Detail Design and Construction contract was awarded to Northrop Grumman Shipbuilding on 15 July 2005, having a fixed price of $2.8 billion for procurement of the first ship in the class. Table 8 is a summary of the LHA 6 budget from 2005 to 2011 for research, development, test and evaluation (RDT&E) and procurement. Procurement funds dramatically increased in 2009–2010 and again in 2010–2011 due to the allocation of funds for LHA 7 and 8. The rise in procurement funds for LHA 6 to $3.167 billion in 2007–2008 can be attributed to the change in design to accommodate the desired aviation platforms along with additional and unexpected costs of onboard self-defense weapon systems. The new total cost estimate for LHA 6 is approximately $4.5 billion, $1.7 billion more than what was originally expected (*Department of the Navy Fiscal Year 2012 Budget Estimates* 15–1). In essence, the Navy looked to save money by eliminating the well deck but ended up spending almost 40 percent more because of the radical change.

Table 8. LHA 6 Cost and Funding (After "Cost & Funding for LHA 6 AMERICA CLASS").

LHA 6 Cost and Funding ($ in millions)		
Transition Year	**RDT&E**	**Procurement**
2005–2006	197.5	2,896
2006–2007	198.8	2,880.1
2007	198.8	3,082.1
2007–2008	200.9	3,167
2009–2010	264.4	6,561.2
2010–2011	327.2	10,996.8

C. PREVIOUS DESIGN MODELS

In order to develop and recommend the best case solution for future amphibious ships for the U.S. Navy, previous ship design models should be examined and analyzed. Lessons learned from prior examples will aid in the success of future developments. The three design models examined here are the U.S. SSN-21 *Seawolf* class submarines, the Japanese World War II Light Aircraft Carriers, and the U.S. LPH *Iwo Jima* class amphibious assault ships.

1. SSN-21 *Seawolf* Class Submarines

The *Seawolf* submarine program began in the 1980s to counter the Soviet Union threat and maintain underwater superiority throughout the remainder of the Cold War. From bow to stern, the *Seawolf* class was designed to have the latest technology any ship had ever seen to operate autonomously against the world's best combatants ("SSN-21 Seawolf-class: Overview"). The primary mission of these highly sophisticated submarines was to hunt, track, and destroy Soviet ballistic missile submarines before they could attack any U.S. targets ("SSN-21 Seawolf-class"). Additionally, *Seawolf* would have the capability to conduct battlespace preparation, intelligence gathering, surveillance, reconnaissance, perform advanced communications, and operate under the polar ice cap for extended periods of time over the span of a 30 year life cycle. The *Seawolf* was designed to have the highest tactical speed of any U.S. submarine, but still being the most silent of all of the stealthy predators hiding beneath the ocean surface ("SSN-21 Seawolf-class: Overview").

The *Seawolf* class, numbering 29 strong, was supposed to be the most dominant submarine force in the world; after all, it would have the best weapons, sensors, communications, and propulsions technology that had ever been developed. The biggest problem for the *Seawolf* program, however, came with the end of the Cold War and fall of the Soviet Union much sooner than anticipated. The top reason why the *Seawolf* submarine was designed and created was to combat the Soviets. With the enemy effectively gone, the need for this new sophisticated weapon dramatically decreased. The second biggest issue that *Seawolf* faced was that by being the best in the world meant being the most expensive in the world. The program was projected to cost approximately $33.6 billion in 1991 for 12 boats, a steep drop from the original 29 that were planned, making it the most expensive submarine ever built in history ("SSN-21 Seawolf-class"). If the Navy continued on with the construction of the *Seawolf* class, it would have spent 25 percent of its budget on a ship designed for an enemy that no longer existed. In 1995 the *Seawolf* program was terminated by Congress, ending the class at three submarines that cost billions of dollars ("SSN-21 Seawolf-class: Overview"). In summary, the reasons for failure of this ship model are as follows:

- Designed a submarine for a future purpose but the future dramatically changed.
- The enemy that the submarine was intended to destroy no longer existed.
- Cost of the program outweighed the benefits.

2. Japanese World War II Light Aircraft Carriers

The initial idea and design for light aircraft carriers was developed in the 1930s by Japan and used by both them and the United States during World War II in the Pacific theater. Japan's purpose for designing and constructing this new type of carrier was for the need to increase ship speed to keep pace with American carriers and to supplement their fleet carriers with additional aircraft (Parshall and Tully 8–9). The first design the Japanese experimented with was the *Ryujo*, which had a single, unobstructed flight deck, two hangar decks, and was considerably shorter at 513 feet long as compared to the fleet carriers which were close to 800 feet. This preliminary design proved to be impractical due to the ship being top-heavy with 48 planes on the flight and hangar decks and it displacing only 8,000 tons. This created a dangerous stability issue and failed to address the requirement of additional speed (Isom 46). Japan fared better in the ensuing designs of their next two carriers, the *Soryu* and *Hiryu*, which were initially called fleet carriers but later classified as light carriers since they displaced only 10,500 tons each and carried 40 aircraft (Isom 47–48). By comparison, the Japanese prized fleet carriers, *Akagi* and *Kaga*, displaced 30,000 to 40,000 tons and carried close to 100 aircraft each (Parshall and Tully 6–8). *Soryu* and *Hiryu* were characterized for their speed due to their cruiser-style hull, lower profile in the water, 152,000 shaft horsepower engines and virtually no heavy armor to weigh the ship down. The design trade-off here was for speed in which protective armor was sacrificed, proving later to hurt the Japanese during crucial battles in the war (Parshall and Tully 9).

Japan's light carrier design had the potential to be the great asset they needed to defeat the United States in the Pacific during World War II. The manner in which they deployed and utilized this asset, along with design flaws, however, is why this particular model failed the Imperial Fleet. The Japanese doctrine and military thought process at the time believed strongly in massing airpower and using large fleet carriers to crush the enemy with a decisive victory (Parshall and Tully 87). Japan won battles at the beginning of the war in the Pacific because they simply brought more carriers with more aircraft to overwhelm their enemy (Parshall and Tully 405). The light carriers were designed to supplement the fleet carriers with additional aircraft, not to hold off the American fleet single handedly. As the war in the Pacific drew on, the Japanese relied too heavily on their light aircraft carriers to perform up to the fleet carrier standard and seemed to forget the original design of those carriers. Several design features contradicted Japanese doctrinal thinking. Overall the light carriers were smaller and naturally carried a smaller amount of aircraft onboard. Because the Japanese maxed out the amount of aircraft onboard the carrier, serious deck-load spotting issues occurred that affected timing of assaults in critical battles. *Soryu* and *Hiryu* had great difficulty spotting a large force because the smaller flight decks could not accommodate extra aircraft and still leave enough run-off room forward for takeoff. The landing cycle also created problems as pilots waiting to land ran out of fuel before aircraft on deck could be moved out of the way (Parshall and Tully 87). The trade-off of speed over armor came in to play during the Battle of Midway as *Soryu* and *Hiryu* were ill-equipped to take and absorb hits which prevented them from continuing to fight in battle (Parshall and Tully 248). Both carriers took immediate and irreparable damage, knocking them out of the battle and removing them from the war (Parshall and Tully 251). In the end, the Japanese light carriers could only play in small roles of the Pacific War due to the size of the air groups, again conflicting with Japanese doctrine, and not having enough room to support and maintain the aircraft, crew, fuel and other aviation necessities onboard (Parshall and Tully 418). The light carriers proved to be inefficient with the costs out-weighing the benefits (Parshall and Tully 419).

To summarize why the Japanese light aircraft carrier model failed:

- Experimental designs that were not fully perfected.
- Unbalanced trade-offs for speed in the ship design, particularly the sacrifice of heavy armor during a major war.
- Employment and design did not fit Japanese doctrine and military thinking.

3. U.S. LPH *Iwo Jima* Class Amphibious Assault Ships

The Amphibious Assault Ship (Helicopter) or Landing Platform Helicopter as it was commonly referred to as, was designed and built in the 1950s to transport up to 1,700 fully equipped Marines into combat areas of operation by landing them ashore using air assets ("LPH-2 IWO JIMA Class: Overview"). The LPH *Iwo Jima* class was the first to be designed and built from the keel up as an amphibious assault ship ("USS Iwo Jima (LPH 2)"). While several follow-on ships in this class were modeled after *USS Iwo Jima* (LPH 2), a few were converted from older escort carriers, making this class a unique group of ships (Polmar 190). The length and displacement of each ship varied because of the mixture of designs and conversions, ranging from 600 to 800 feet and 20,000 to 40,000 tons respectively ("LPH-2 IWO JIMA Class: Overview"). Similar to that of the Japanese World War II light aircraft carriers, the initial LPH was a preliminary design for a specific amphibious assault ship. LPHs could accommodate a full Marine battalion and operate both rotary and fixed winged aircraft; however, it did not have a wet well for amphibious landing craft (Polmar 190).

Essentially, the LPHs were another type of light aircraft carrier with a specific focus on Marine aviation. This ship design was not a complete failure as it was utilized with success throughout the wars of the 1950s to the early 1990s, but was limited in its capabilities and functions. LPHs caused a shift in the Navy and Marine Corps' thought and design process as together each service realized that having both a well deck and flight deck was essential to conducting successful amphibious operations ("Marine Question the Utility of Their New Amphibious Warship"). The Marines, being the versatile force they are, have always required the ability to operate on air, land, and sea. Limiting the capabilities onboard the LPHs resulted in limiting the Marine Corps capabilities to get ashore and accomplish the mission. The correct assessment was made in the 1950s that the Navy and Marine Corps team needed a ship specifically used for amphibious assault, however, the design put an unnecessary limit on how the Marines landed and hindered their capabilities.

To summarize why the LPH model failed:

- The employment and design did not fit the U.S. Navy and Marine Corps doctrine.
- Limited the capabilities of the landing force.

4. Lessons Learned

Several conclusions can be drawn from the previous three design models:

- No one can truly predict what the future will bring, but it can be bounded. Designs should be flexible enough to allow relative changes and leave room for growth and development.
- No matter what, it will cost a substantial amount of money to develop, design, and construct any new ship. While all too often money is the driving factor in making design decisions, in a perfect world, it should be a balance between the needs, requirements, and cost.
- Fitting a round peg in a square hole still will not work. Ship design should fit the accepted doctrine and training of the Navy and Marine Corps and not vice versa.
- Mediocre models can lead to great models. Instead of throwing out previous models and starting from scratch, make changes to improve the ones already in place.
- Learn from past mistakes. Study the history and thinking behind each relative design model to learn best practices of what to do and what not to do.

D. CHAPTER SUMMARY

This chapter examined the new amphibious assault ship model and the important design changes associated with the new LHA class. The load configurations of the ship along with its expected aviation assets were also discussed. The *America* class LHAs will be dominated by the MV-22 *Osprey* and the F-35 Joint Strike Fighter but lack the defining characteristic of an amphibious ship: the well deck. Through the examination of the acquisition life cycle, it was discovered how design decisions are normally made in the notional shipbuilding process. The LHA (R) Program followed this process to a certain extent and then shifted when a major design decision occurred well after the plans for construction were finalized with no revisit or evaluation of the requirements set in the Mission Need Statement. Finally, previous design models were analyzed to discover lessons learned from past miscalculations in order to best determine and recommend the future course of action for amphibious design. The impacts and analysis of these amphibious design decisions will be discussed in the next chapter.

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IV. AMPHIBIOUS MODEL DATA ANALYSIS

A. COMPARISON OF CURRENT AND FUTURE AMPHIBIOUS MODELS

The LHA *Tarawa* class and LHA (R) *America* class of amphibious assault ships represent two different amphibious models in the United States Navy. While the future *America* class is set to replace the older *Tarawa* class ships in the fleet, each have significant differences in design and amphibious lift capacity. A comparison and analysis has been performed using the lift footprints and data presented for both ship classes, which is summarized in Table 9. From the side by side comparison of both classes, looking solely at the numerical data for each, it was determined that the LHA *Tarawa* class has a stronger advantage over the LHA *America* class in most categories.

Table 9. LHA *Tarawa* Class vs. LHA (R) *America* Class.[1]

LHA *Tarawa* Class and LHA (R) *America* Class Comparison			
Lift Footprints	**LHA *Tarawa* Class**	**LHA (R) *America* Class**	**Advantage**
Troop Berthing	2,000	1,871	*Tarawa*
Vehicle Square (SqFt)	25,400	10,328	*Tarawa*
Cargo Cube (CuFt)	105,900	160,000	*America*
Aircraft (CH-46 Eq)	42	45	*America*
LCAC Spots	1	0	*Tarawa*
Characteristics	**LHA *Tarawa* Class**	**LHA (R) *America* Class**	
Max Speed (knots)	24	22	*Tarawa*
Cruising Speed (knots)	20	14–17	*Tarawa*
Range (nautical miles)	10,000	10,000	*Even*
Medical Capability	4 OR, 17 ICU, 48 Ward, 4 Isolation	2 OR, 24 Ward	*Tarawa*
Hangar Bay (SqFt)	18,104, 4 frames high	25,937, 7 frames high	*America*
LCU Spots	2–4	0	*Tarawa*
AAVs Embarked	45	0	*Tarawa*

[1] Information gathered from various sources: ("LHA 6 Information" 4–6, "LHA-1 Tarawa Class," Tucker 101, and "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)").

The lift footprints are essential characteristics of amphibious ships that depict the total capacity of assault shipping utilized in amphibious operations (*Joint Publication 1–02: Department of Defense Dictionary of Military and Associated Terms* 20). These five figures are vital to amphibious operational planning and preparation as they express how many troops can be embarked, how much equipment and supplies can be carried, and amount of vehicles and aircraft that can be utilized and stowed aboard. Exploring each of the five footprints line by line shows that the *Tarawa* class holds a greater advantage in three of these categories: troop berthing, vehicle square footage, and LCAC spots. Troop berthing is the amount of racks, or beds, on board the ship which corresponds to the number of Marines that can be embarked on board at a given time. The *Tarawa* class has roughly a 130 to 150 rack advantage over that of the *America* class, allowing it to fit the required number of personnel in a typical MEU on board. The MEU is organized and manned with a certain number of personnel based off of the amount of space allotted on board. Decreasing the amount of racks available on the LHA *America* class will force the MEU commanders to reorganize their troops and possibly leave important assets behind on the pier. Much the same can be said regarding the amount of square feet for vehicle stowage. The *Tarawa* class has about 15,000 square feet more room for vehicles than the *America* class. Again the MEU is organized to depend upon a set configuration of vehicles required for amphibious operations and will be forced to restructure typical plans and procedures while leaving valuable assets on the pier.

While the difference between the numbers of LCAC spots is one between the *Tarawa* and *America* class, the significance of that one spot is of great proportion considering the controversy surrounding the removal of the well deck. The one spot represents the absence or presence of an entire sealift capability. As described in the previous chapters, the *America* class will not have any landing craft capabilities due to the deletion of the well deck from the new LHA design. By taking away a crucial capability, the defining feature of the amphibious assault ship, it clearly gives the advantage to the *Tarawa* class by immense proportions. Removal of the well deck automatically limits the lift capabilities of the ship to land Marines along with their equipment, supplies, cargo, and vehicles ashore. While the LHA *America* class has less vehicle stowage space, the Sailors and Marines onboard will still have to contend with getting which ever vehicles were embarked to the beach using only the available rotary wing aircraft. Landing the troops and their equipment ashore during any amphibious operation will become much more complicated, complex, time consuming, and dangerous if air assets are the only available means of transportation. It may also expose a great shortfall in the reduced number of operating rooms and ward beds. Eliminating the well deck capability and thereby decreasing the assets that the landing force has available violates the proven OMFTS and STOM doctrinal principles that are utilized by both the Navy and Marine Corps. Both documents preach overwhelming operational tempo that overpowers the enemy, not giving them time to react to the situation.

An essential element of this principle is the elimination of an operational pause once the landing force has reached the objective area. With both a landing craft and aircraft capability, the LHA *Tarawa* class ships have the ability to achieve these principles as Marines, their equipment, vehicles, and supplies land ashore almost all at once. The LHA *America* class will not support the OMFTS and STOM doctrine as its lone aviation assets will not be able to maintain a fast operational tempo due to the lift capabilities and restrictions placed on the aircraft. Amphibious landings will take a lot longer since each vehicle, piece of cargo, equipment, and Marine personnel transfer must be airlifted separately ashore. Physics and aircraft safety procedures prevent a full load of Marines in the helicopter while slinging heavy loads beneath it with the cargo hook. From a mission specific viewpoint, the removal of the well deck severely limits the ship's potential contributions during a major amphibious assault because of the reasons just mentioned (Work 222). It also takes away the ability to gain access to ports, especially those destroyed in natural disasters, preventing the LHA *America* class from being an effective asset in humanitarian operations. The projection of power and combat missions will change for the *America* class as it shifts to the aircraft carrier mentality and away from the amphibious approach. Two other characteristics listed in Table 9 that are not one of the footprints but related to number of LCAC spots are number of LCUs and AAVs that each class can carry. Depending on the configuration, the *Tarawa* class can embark two or four LCUs or 45 AAVs at a given time. Again, since the *America* class does not have well deck and therefore cannot carry landing craft, the advantage obviously goes to the *Tarawa* class. Eliminating the well deck will force the Marine Corps to change and restructure how they plan for and conduct amphibious operations along with pushing them away from proven tactics, techniques, and procedures found in current Navy and Marine Corps doctrine.

The well deck issue also comes into play with the last two lift footprints of cargo space and aircraft spots, which, by numerical value, the *America* class has the advantage over the *Tarawa* class. The new LHA will have roughly 54,000 more cubic feet of cargo space available on board the ship. More cargo space is definitely a great benefit; however, the same lift problem arises with getting the required cargo ashore to the objective area with only air assets that add to the weight constraints. The additional space can also be misleading as most of it came from the removal of the well deck to be utilized for extra aircraft part and supply storage. In reality the added space will be used for the upkeep and maintenance of the space consuming MV-22 *Osprey* and F-35 Joint Strike Fighter and not for additional amphibious operational needs. The *America* class also has a slight advantage in amount of aircraft spots by three over the *Tarawa* class since it was designed after an LHD model that accommodates for a slightly larger number of aircraft. The relative significance of this advantage is small and is not a major contributing factor to the amount of MV-22 Osprey or F-35 Joint Strike Fighters that the new LHA will be able to embark.

The several other characteristics listed in Table 9 are also important to note since they play a role in amphibious assault ship missions as well. The maximum and cruising speeds of each class of ship are mentioned to demonstrate another design shift on board large deck amphibious ships. The older LHA *Tarawa* class ships are powered by steam turbines that give it a two knot maximum speed advantage and a few knot cruising speed advantage over its replacement. With a push to save money on fuel and use more economical ways to conserve on gas in the Navy, the LHA *America* class, like that of its design model LHD 8, will be a hybrid of gas turbine and electric power. While this newer propulsion design slightly drives down the maximum and cruising speeds of the new LHA class, it provides a more efficient gas mileage as times between refueling increase.

The *Tarawa* class has the speed advantage while the *America* class has the benefit of newer propulsion technology. Relating to speed is the range of each ship as it represents the maximum distance the ships can travel without refueling. The *America* class is expected to have about the same range of 10,000 nautical miles as the *Tarawa* class, making the advantage even in this category. Both classes also have the ability to refuel at sea which thereby extends their range to travel all throughout the globe.

The next two characteristics are interrelated due to the removal of the well deck and making the LHA *America* class an aviation only platform for the MV-22 *Osprey* and F-35 Joint Strike Fighter. The medical space and capabilities on board the *Tarawa* class is roughly double that of the *America* class since the hangar bay was extended both horizontally and vertically to support aircraft maintenance and storage for the new air assets. The *America* class lost two operating rooms, the *entire* intensive care unit, 24 ward beds, and the isolation space, leaving it with just two operating rooms and 24 ward beds total. This greatly hinders the ship's ability to render assistance on board during humanitarian operations, one of the main missions amphibious assault ships have been assigned. Limiting the medical facilities on board a ship with a large crew and embarked landing force is a serious disadvantage and major risk, especially if there is a mass casualty situation on board or an amphibious withdrawal when Marines will need medical attention. Amphibious assault ships are greatly relied upon for their mobile medical facilities and personnel by the Joint Force Commander in operational theaters throughout the world. As humanitarian operations are becoming more routine missions for the Navy and Marine Corps, extensive medical facilities along with the capability to carry specialized teams, doctors, and other essential medical personnel are required to perform these objectives. The design decision to make room for costly air assets does not match the current operational mentality and contradicts the Navy's mission statement of being a "Global Force for Good." Like the well deck, the large medical ward on board amphibious assault ships is another unique, essential feature and asset that they bring to the fleet and to the mission.

In general, the comparison and analysis between the two classes of ships shows a significant number of trade-offs made to ensure that two struggling and financially burdening aircraft have a place to call home. Capabilities that the Navy and Marine Corps have come to rely on will no longer be at their disposal. The removal of the well deck is the most radical change and is a major trade-off in favor of the aviation platform. As determined from the lessons learned in three previous design models described in Chapter III, no one can truly predict what the future will bring. At the same time, the Navy and design contractors violated one of the most important lessons learned in just about any situation: learn from past mistakes. The Navy and Marine Corps already tried the amphibious assault ship without a well deck once in the 1950s with the deployment of the LPH *Iwo Jima* class. From that design mistake it was already determined that both a well deck and flight deck were a vital necessity to conduct effective amphibious operations. The wrong color green was used to make these radical changes in amphibious design as cost drove the LHA (R) Program instead of requirements and performance. Making crucial trade-offs for unproven aircraft, such as sacrificing a full medical facility is unwise. The new LHA design is forcing the amphibious fleet to dramatically change their doctrine, training, and known practices because it needs to change for the sake of changing. One conflict in a land locked area does not determine that every conflict in the future will be exactly the same. Missions and operational environments change from war to war and conflict to conflict. Limiting the Navy and Marine Corps' future capabilities will take away the unique, powerful, and advantageous assets that are unmatched by any enemy throughout the world. As seen through the comparison of the two ships, the older *Tarawa* class has a much bigger advantage over the *America* class in almost every category of amphibious operations.

B. LIFT EQUATIONS

To further demonstrate the effects of removing the well deck in the new LHA amphibious assault ship, several lift equations were developed from the typical landing craft and aircraft configurations of the current and future amphibious models. These equations were used in calculating the amount of time required to conduct an amphibious landing in order to prove which LHA configuration was the most efficient and effective. The five aircraft and landing craft configurations, as described in Chapters II and III, include:

- LHA 1: 1 LCAC/2 LCUs for equipment transfer, 12 CH-46s/4 CH-53s for personnel transfer.
- LHA 1: 4 LCUs for equipment transfer, 12 CH-46s/4 CH-53s for personnel transfer.
- LHA 1: 45 AAVs for personnel transfer one way, 12 CH-46s/4 CH-53s for personnel transfer.
- LHA 6: Combined Aircraft Configuration, 12 MV-22s for equipment and personnel transfer.
- LHA 6: MEU Mix Aircraft Configuration, 12 MV-22s/4 CH-53s for equipment and personnel transfer.

LHA 1 refers to the overall *Tarawa* class while LHA 6 refers to the overall *America* class. The terms "LHA 6," "*America* class," "new LHA," and "LHA (R)" are all synonymous in this chapter. The LHA 1 AAV configuration is treated differently as AAVs are owned and operated by Marines and will stay with the MEU on the beach; hence the one way calculation ashore. The AAV configuration is not a typical landing craft load out used to transfer equipment ashore since their purpose is to transport Marines and a small amount of cargo to the beach during an opposed landing. This configuration is still included to demonstrate another available asset to the landing force to conduct opposed landings if necessary.

The aircraft chosen in the lift equations are based on the typical Marine ACE embarked onboard each ship. The current ACE assets include: 12 CH-46 *Sea Knights*, four CH-53 *Sea Stallions*, three UH-1 *Hueys*, four AH-1 *Super Cobras*, and six AV-8B *Harriers*. The *Super Cobra* and *Harrier* aircraft are only used for strike purposes and do not have any lift abilities. The *Huey* is used for command and control and aerial reconnaissance and also does not have any lift ability. This leaves the *Sea Knight* and *Sea Stallion* to do the heavy lifting. The future ACE assets are reflected within the two expected aircraft configurations onboard the *America* class: Combined and MEU Mix. The Combined Configuration will have 12 MV-22 *Ospreys* and 12 F-35 Joint Strike Fighters as all the lifting ability will reside with the *Osprey*. The MEU Mix will consist of 12 MV-22 *Ospreys*, six F-35 Joint Strike Fighters, seven AH-1/UH-1 *Hueys* and *Super*

Cobras combined, and four CH-53 *Sea Stallions*. This again just leaves the *Osprey* and the *Sea Stallion* to conduct the personnel and equipment lifts of the amphibious operation.

The assumption made for the lift equations was that each landing craft and aircraft would utilize their maximum lift capability, as described in Chapters II and III and Appendices A and B. The five lift equations developed are as follows:

Table 10. Amphibious Lift Equations.

LHA 1: 1 LCAC/2LCUs for equipment, 12 CH-46s/4 CH-53s for personnel
1 LCAC + 2 LCUs = 1 wave 75 tons + 2*(170 tons) = 415 tons/wave 12 CH-46s + 4 CH-53s = 1 wave (12 CH-46s)*(17 personnel) + (4 CH-53s)*(55 personnel) = 424 personnel/wave

LHA 1: 4 LCUs for equipment, 12 CH-46s/4 CH-53s for personnel
4 LCUs = 1 wave 4*(170 tons) = 680 tons/wave 12 CH-46s + 4 CH-53s = 1 wave (12 CH-46s)*(17 personnel) + (4 CH-53s)*(55 personnel) = 424 personnel/wave

LHA 1: 45 AAVs for personnel one way, 12 CH-46s/4 CH-53s for personnel
45 AAVs = 1 wave 45*(24 Marines, which include 3 crew members) = 1,080 personnel per/wave 12 CH-46s + 4 CH-53s = 1 wave (12 CH-46s)*(17 personnel) + (4 CH-53s)*(55 personnel) = 424 personnel/wave

LHA 6: Combined Aircraft Configuration, 12 MV-22s for equipment and personnel
12 MV-22s = 1 wave Personnel: (12 MV-22s)*(24 personnel) = 288 personnel/wave Equipment: MV-22 can only lift 1 piece of equipment at a time; single hook up to 5 tons and dual hook up to 7.5 tons (12 MV-22s)*(1 vehicle/cargo hook load) = 12 loads/wave

LHA 6: MEU Mix Aircraft Configuration, 12 MV-22s/4 CH-53s for equipment and personnel
12 MV-22s + 4 CH-53s = 1 wave Personnel: (12 MV-22s)*(24 personnel) + (4 CH-53s)*(55 personnel) = 508 personnel/wave Equipment: MV-22 can only lift 1 piece of equipment at a time; single hook up to 5 tons and dual hook up to 7.5 tons; CH-53 can only lift 1 piece of equipment at a time up to 13 tons (12 MV-22s)*(1 vehicle/cargo hook load) + (4 CH-53s)*(1 vehicle/cargo hook load) = 16 loads/wave

Each of these five equations can be applied to their respective ship classes to an amphibious landing situation to determine the amount of time each configuration will take to conduct an operation. The example amphibious situation that these equations will be applied to in this thesis is the transfer of equipment and personnel from the LHA to the amphibious objective area ashore 25 nautical miles away. This is an arbitrary distance chosen to represent an over the horizon amphibious landing that keeps the ship far enough away from land to avoid visual detection. The amount of personnel in the landing force was the maximum amount that each ship class could embark. For LHA 1 it is 2,000 personnel and for LHA 6 it is 1,871 personnel. The equipment chosen in this scenario represents the principle weapons, equipment, and vehicles in an average MEU, which are depicted in Table 11.

Table 11. Example of Typical MEU Equipment.[2]

Example of Typical MEU Equipment			
Equipment	**Number**	**Weight of 1 Unit**	**Total Tons**
M1A1 Tank	4	70 tons	280
LAV	16	14.1 tons	225.6
155 mm Howitzers	6	5 tons	30
81 mm Mortars	8	90 pounds	0.36
60 mm Mortars	12	50 pounds	0.3
MK19 40 mm	24	120 pounds	1.44
TOW Launchers	8	305 pounds	1.22
Javelins	8	20 pounds	0.08
.50 Cal Machine Guns	24	124 pounds	1.488
HMMWV	92	2.6 tons	239.2
7 Ton Trucks	30	7 tons	210
Forklift	1	6.75 tons	6.75
D7 Dozer	1	25 tons	25
ROWPUS	2	3.65 tons	7.3
		Total	1028.738
Rounded for Calculations: 1,000 tons of equipment total			

[2] Information gathered from various sources: ".50 Cal Machine Gun: Specifications," "Caterpillar D7 Bulldozer," "CH-53E Super Stallion," "FGM-148 Javelin," "History: CH-46 Sea Knight," "M1AI Abrams Tank," "M777 Lightweight 155mm howitzer," "Mark 19," "United States Marine Corps: Roles & Missions" 28, "United States Marine Corps Weapons & Equipment: High Mobility Multipurpose Wheeled Vehicle (HMMWV) (M998 Truck)," "United States Marine Corps Weapons & Equipment: Light Armored Vehicle-25 (LAV-25)," "United States Marine Corps Weapons & Equipment: M224 60mm Lightweight Mortar," "United States Marine Corps Weapons & Equipment: M252 81mm Medium Extended Range Mortar," "United States Marine Corps Weapons & Equipment: Reverse Osmosis Water Purification Unit," and "United States Marine Corps Weapons & Equipment: Tube Launched, Optically Tracked, Wire Guided (TOW) Missile Weapon System."

There were several assumptions made in this amphibious situation to limit the variables and complexity of the calculations. The purpose of these time/distance computations is to prove which class of ship is more efficient and effective at completing its primary mission of amphibious landings. These calculations are solely looking at the numerical values of number of personnel and equipment weight in tons to determine the amount of time to and from the beach and total time of the amphibious landing. Loading and embarkation plans on board the ship, landing craft, and aircraft were not considered since there are numerous ways to configure each for beach landings. For LHA 1, it was assumed that the landing craft would lift and transfer all equipment ashore while the helicopters lifted all personnel. For LHA 6, it could only be assumed that equipment and personnel were lifted by helicopter. Other variables held constant and assumed to have the same affects in each situation of this analysis were crew rest, aircraft breakdowns and maintenance, refueling time, loading time on the ship, and weather restrictions. Lastly, arbitrary offload times at the beach were assumed and incorporated into the round trip time of each landing craft and aircraft. These assumptions are illustrated in Table 12. The equipment offload times for each helicopter is zero since each piece is being carried by hook under the aircraft and dropped off at the beach without the helicopter landing. Essentially it takes no time to drop the piece of equipment off at the beach before starting the return trip back to the ship.

Table 12. Craft Offload Time Assumptions.

Offload Time Assumptions	
Craft	**Time**
LCAC	10 min.
LCU	15 min.
AAV	N/A
CH-53 Personnel	3 min.
CH-53 Equipment	0 min.
CH-46 Personnel	2 min.
CH-46 Equipment	0 min.
MV-22 Personnel	3 min.
MV-22 Equipment	0 min.

The time/distance calculations for each landing craft and aircraft are shown in Table 13. These calculations along with the lift equations were applied to the amphibious landing situation to determine lift times for each configuration. The time/distance calculations for each of the five configurations can be seen in Table 14. Figure 5 is a visual representation of the amount of time it takes each craft to reach the beach along with their respective assumed offload times. A summary of the final lift times for each configuration is shown in Table 15.

Table 13. Time/Distance Calculations for Each Landing Craft and Aircraft.

LCAC
Speed = 40 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/40 kts = 0.625 hours = 37.5 minutes to the beach Round Trip = 1 hour 15 minutes + 10 minute offload time LCAC Round Trip = 1 hour 25 minutes

LCU
Speed = 11 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/11 kts = 2.27 hours = 2 hours 16 minutes to the beach Round Trip = 4 hours 32 minutes + 15 minute offload time LCU Round Trip = 4 hours 47 minutes

AAV
Speed = 5 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/5 kts = 5 hours to the beach AAV One Way Trip = 5 hours

CH-46
Speed = 135 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/135 kts = 0.185 hours = 11 minutes to the beach Round Trip = 22 minutes Round Trip Personnel = 22 minutes + 2 minutes offload time = 24 minutes

CH-53
Speed = 160 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/160 kts = 0.15625 hours = 9 minutes to the beach Round Trip = 18 minutes Round Trip Personnel = 18 minutes + 3 minutes offload time = 21 minutes

MV-22
Speed = 250 knots, Distance = 25 nautical miles, Time = Distance/Speed Time = 25 nm/250 kts = 0.1 hours = 6 minutes to the beach Round Trip = 12 minutes Round Trip Personnel = 12 minutes + 3 minutes offload time = 15 minutes

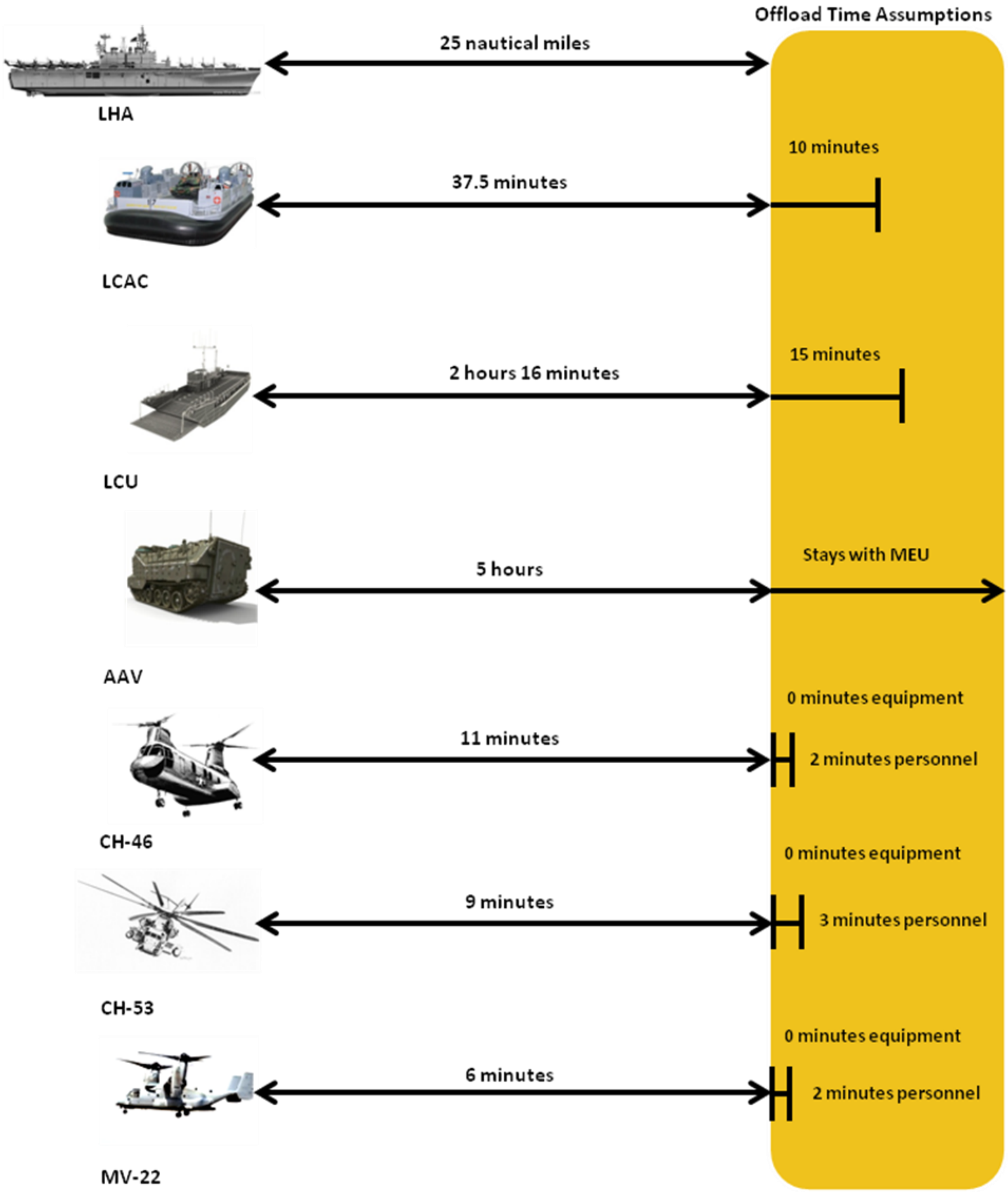

Figure 5. Craft Travel Time to Amphibious Objective Area with Offload Time Assumptions.

Table 14. Time/Distance Calculation for Each Configuration.

LHA 1: 1 LCAC/2LCUs for equipment, 12 CH-46s/4 CH-53s for personnel
LHA 1 Personnel = 2,000 Equipment Weight = 1,000 tons
Equipment: 1 LCAC + 2 LCUs = 1 wave, 415 tons lift/wave
Number of Waves = 1,000 tons/415 tons lift/wave = 2.4 waves
2.4 waves = 2 waves + 1 LCU
Total Craft = 2*(1 LCAC + 2 LCUs) + 1 LCU = 2 LCACs + 5 LCUs
Total Time = 2*(1 hr. 25 min.) + 5*(4 hr. 47 min.)
Total Equipment Lift Time = 26 hours 45 minutes
Personnel: 12 CH-46s + 4 CH-53s = 1 wave, 424 personnel/wave
Number of Waves = 2,000 personnel/424 personnel/wave = 4.7 waves
4.7 waves = 4 waves + 4 CH-53s + 4 CH-46s
Total Craft = 4*(12 CH-46s + 4 CH-53s) + 4 CH-53s + 4 CH-46s
Total Craft = 52 CH-46s + 20 CH-53s
Total Time = 52*(24 min.) + 20*(21 min.)
Total Personnel Lift Time = 27 hours 48 minutes
Total Lift Time = 54 hours 33 minutes

LHA 1: 4 LCUs for equipment, 12 CH-46s/4 CH-53s for personnel
LHA 1: Personnel = 2,000 Equipment Weight = 1,000 tons
Equipment: 4 LCUs = 1 wave, 680 tons lift/wave
Number of Waves = 1,000 tons/680 tons lift/wave = 1.47 waves
1.47 waves = 1 wave + 2 LCUs
Total Craft = 1*(4 LCUs) + 2 LCUs = 6 LCUs
Total Time = 6*(4 hrs. 47 min.)
Total Equipment Lift Time = 28 hours 42 minutes
Personnel: 12 CH-46s + 4 CH-53s = 1 wave, 424 personnel/wave
Number of Waves = 2,000 personnel/424 personnel/wave = 4.7 waves
4.7 waves = 4 waves + 4 CH-53s + 4 CH-46s
Total Craft = 4*(12 CH-46s + 4 CH-53s) + 4 CH-53s + 4 CH-46s
Total Craft = 52 CH-46s + 20 CH-53s
Total Time = 52*(24 min.) + 20*(21 min.)
Total Personnel Lift Time = 27 hours 48 minutes
Total Lift Time = 56 hours 30 minutes

LHA 1: 45 AAVs for personnel one way, 12 CH-46s/4 CH-53s for personnel
LHA 1 Personnel = 2,000
Personnel: 45 AAVs = 1 wave, 1 way, 1,080 personnel/wave
Number of Waves = 1
Total Personnel Lift Time AAV = 5 hours
Personnel: 920 remaining to be lifted by helicopter

Personnel: 12 CH-46s + 4 CH-53s = 1 wave, 424 personnel/wave Number of Waves = 920 personnel/424 personnel/wave = 2.17 waves 2.17 waves = 2 waves + 1 CH-53 + 1 CH-46 Total Craft = 2*(12 CH-46s + 4 CH-53s) + 1 CH-53 + 1 CH-46 Total Craft = 25 CH-46s + 9 CH-53s Total Time = 25*(24 min.) + 9*(21 min.) **Total Personnel Lift Time Helicopter = 13 hours 9 minutes** **Total Personnel Lift Time = 18 hours 9 minutes**

LHA 6: Combined Aircraft Configuration, 12 MV-22s for equipment and personnel
LHA 6 Personnel = 1,871 Equipment Weight = 1,000 tons Equipment: Can only lift 1 vehicle/piece of cargo at a time, 1 wave = 12 MV-22s *Lose 4 M1A1 Tanks, 16 LAVs and 1 D7 Dozer because of weight limit 6 trips for 6 Howitzers (1 at a time) 1 trip for 8 81 mm & 12 60 mm Mortars (combined cargo sling) 1 trip for 24 Mk-19s (cargo sling) 1 trip for 8 TOW Launchers (cargo sling) 1 trip for 8 Javelins (cargo sling) 1 trip for 24 .50 Cal Machine Guns (cargo sling) 92 trips for 92 HMMWVs (1 at a time) 30 trips for 30 7 Ton Trucks (1 at a time) 1 trip for 1 Forklift 2 trips for 2 ROWPUS (1 at a time) Total Trips = 136 Total Craft = 136 trips/12 MV-22s/wave = 11.33 waves 11.33 waves = 11 waves + 4 MV-22s = 136 MV-22s Total Time = 136*(12 min.) **Total Equipment Lift Time = 27 hours 12 minutes** Personnel: 12 MV-22s = 1 wave, 288 personnel/wave Number of Waves = 1,871 personnel/288 personnel/wave = 6.5 waves 6.5 waves = 6 waves + 6 MV-22s Total Craft = 6*(12 MV-22s) + 6 MV-22s Total Craft = 78 MV-22s Total Time = 78*(15 min.) **Total Personnel Lift Time = 19 hours 30 minutes** **Total Lift Time = 46 hours 42 minutes**

LHA 6: MEU Mix Aircraft Configuration, 12 MV-22s/4 CH-53s for equipment and personnel
LHA 6 Personnel = 1,871 Equipment Weight = 1,000 tons Equipment: Can only lift 1 vehicle/piece of cargo at a time, 1 wave = 12 MV-22s + 4 CH-53s

*Lose 4 M1A1 Tanks, 16 LAVs and 1 D7 Dozer because of weight limit
6 trips for 6 Howitzers (1 at a time)
1 trip for 8 81 mm & 12 60 mm Mortars (combined cargo sling)
1 trip for 24 Mk-19s (cargo sling)
1 trip for 8 TOW Launchers (cargo sling)
1 trip for 8 Javelins (cargo sling)
1 trip for 24 .50 Cal Machine Guns (cargo sling)
92 trips for 92 HMMWVs (1 at a time)
30 trips for 30 7 Ton Trucks (1 at a time)
1 trip for 1 Forklift
2 trips for 2 ROWPUS (1 at a time)
Total Trips = 136
Total Craft = 136 trips/(12 MV-22s + 4 CH-53s/wave) = 8.5 waves
8.5 waves = 8 waves + 8 MV-22s
Total Craft = 8*(12 MV-22s + 4 CH-53s) + 8 MV-22s
Total Craft = 104 MV-22s + 32 CH-53s
Total Time = 104*(12 min.) + 32*(18 min.)
Total Equipment Lift Time = 30 hours 24 minutes
Personnel: 12 MV-22s + 4 CH-53s = 1 wave, 508 personnel/wave
Number of Waves = 1,871 personnel/508 personnel/wave = 3.68 waves
3.68 waves = 3 waves + 4 CH-53s + 6 MV-22s
Total Craft = 3*(12 MV-22s + 4 CH-53s) + 4 CH-53s + 6 MV-22s
Total Craft = 42 MV-22s + 16 CH-53s
Total Time = 42*(15 min.) + 16*(21 min.)
Total Personnel Lift Time = 16 hours 6 minutes
Total Lift Time = 46 hours 30 minutes

Table 15. Summary of Lift Time Calculations for Each Configuration.

Configurations	Equipment Lift Time	Personnel Lift Time	Combined Time	Simultaneous?	Actual Max. Time
LHA 1: 1 LCAC/2 LCUs	26 hrs. 45 min.	27 hrs. 48 min.	54 hrs. 33 min.	Yes	27 hrs. 48 min.
LHA 1: 4 LCUs	28 hrs. 42 min.	27 hrs. 48 min.	56 hrs. 30 min.	Yes	28 hrs. 42 min.
LHA 1: 45 AAVs*	5 hrs.	13 hrs. 9 min.	18 hrs. 9 min.	Yes	13 hrs. 9 min.
LHA 6: Combined	27 hrs. 42 min.	19 hrs. 30 min.	46 hrs. 42 min.	No	46 hrs. 42 min.
LHA 6: MEU Mix	30 hrs. 24 min.	16 hrs. 6 min.	46 hrs. 30 min.	No	46 hrs. 30 min.

*Assumed personnel transfers ashore only combined with personnel transfers by LHA 1 helicopter configuration. Not a suitable landing craft configuration for transporting both equipment and personnel ashore. Time for AAVs is one-way only. AAV Equipment Lift Time is lift of personnel in AAV landing craft, Personnel Lift Time is lift of personnel by helicopter.

From the data and calculations, it can be concluded that the *Tarawa* class LHAs are more effective and efficient at amphibious landings than the *America* class LHAs will be. While the combined lift times for LHA 1 are greater than the LHA 6 as seen in Figure 7, the actual total lift times, as seen in Figure 8, are substantially smaller since landing craft and aircraft lift occur simultaneously. The *America* class will not have the luxury of a dual amphibious lift capability and will effectively take twice as long to conduct an amphibious landing ashore. Of the five configurations, the "LHA 1: 1 LCAC/2 LCUs" is the most efficient as it combines both speed, with the LCAC, and gross tonnage lift, with the LCUs, together along with a concurrent means of transporting personnel ashore. The least efficient means of conducting an amphibious landing is with the "LHA 6: Combined" configuration as it only has 12 MV-22s to lift both equipment and personnel ashore. Both LHA 6 configurations had 129 less personnel to transport than the LHA 1 configurations and both failed to transport all of the required MEU equipment. Because of the lift weight limits on board the MV-22 and CH-53, four M1A1 Tanks, 16 Light Armored Vehicles (LAVs), and one D7 Dozer could not be transported ashore.

The comparison of equipment and personnel lift time results, seen in Figures 5 and 6, are interesting to note as the slower landing craft on LHA 1 prove to be the faster means to transport equipment ashore while the helicopters on LHA 6 are the fastest means to transport personnel to the beach. The equipment lift times are slower in the LHA 6 configurations since each piece is airlifted one at a time. The "LHA 6: MEU Mix" configuration was expected to have a faster equipment lift time than the "LHA: Combined" since it has four additional aircraft to carry the loads. However, it was proved that more is not necessarily better as it took the MEU Mix almost three additional hours to transport the equipment ashore due to the CH-53's longer flight time to the beach than the MV-22. These results also show that while the new air assets on board LHA 6 may transport personnel ashore at a faster rate they will have to sit on the beach, vulnerable, for an additional 27 to 30 hours waiting for all their equipment to arrive before carrying out the mission. The best configuration in this realistic amphibious landing situation would therefore be a combination of one LCAC and two LCUs for equipment transport along with the MEU Mix for personnel transport ashore, which would require the ship to have both a well deck and flight deck capability.

For this particular situation, the AAV configuration would not be feasible because it does not fit the purpose of the event nor the event fitting the purpose of the AAV. Because of this, the AAV configuration was left out of the comparisons in Figures 6 through 9. Again, AAVs are Marine owned and operated and stay with the MEU throughout their mission. Due to the slow speed of the AAVs through the water, they typically will not be launched from the ship more than five nautical miles from shore. Removal of the well deck affects this Marine Corps capability as they not only lose a means to storm the beach during an opposed landing but also lose a land based troop and cargo transport as well.

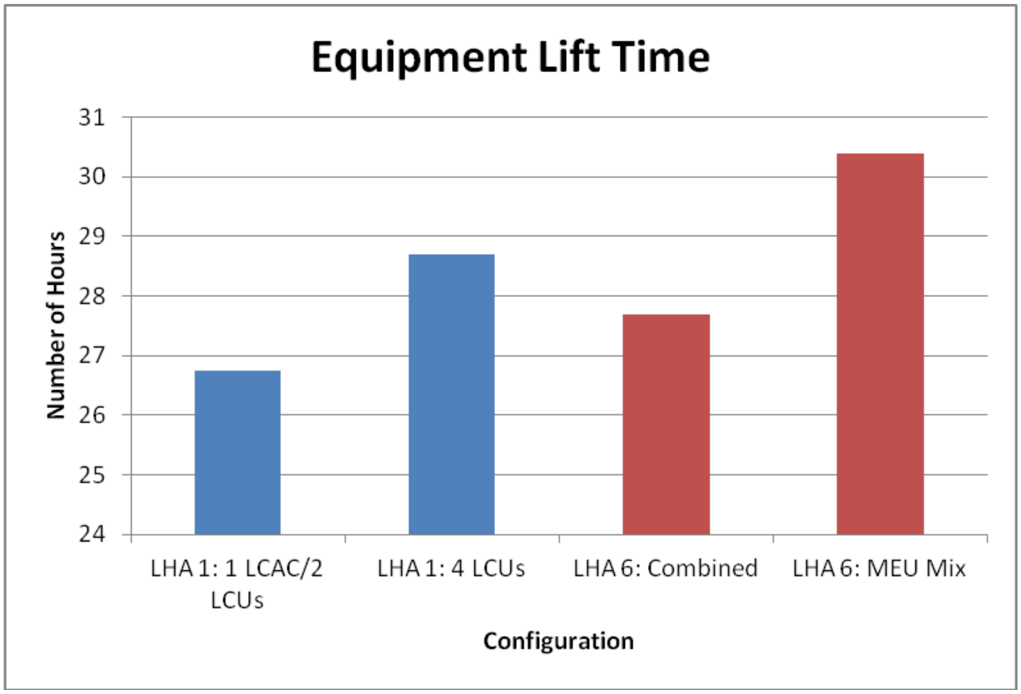

Figure 6. Equipment Lift Time.

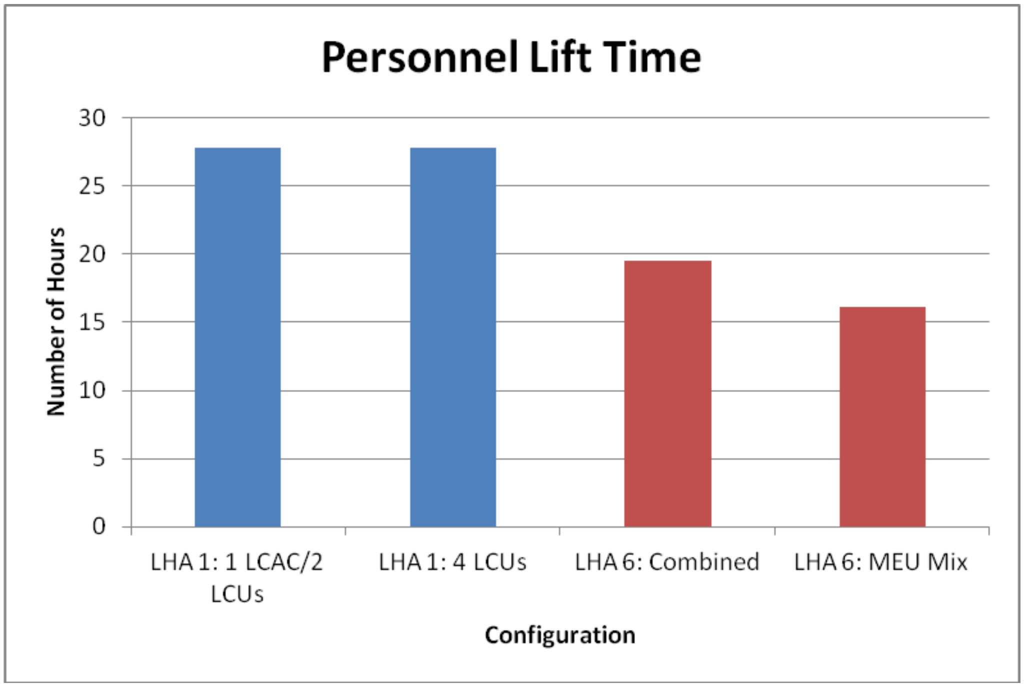

Figure 7. Personnel Lift Time.

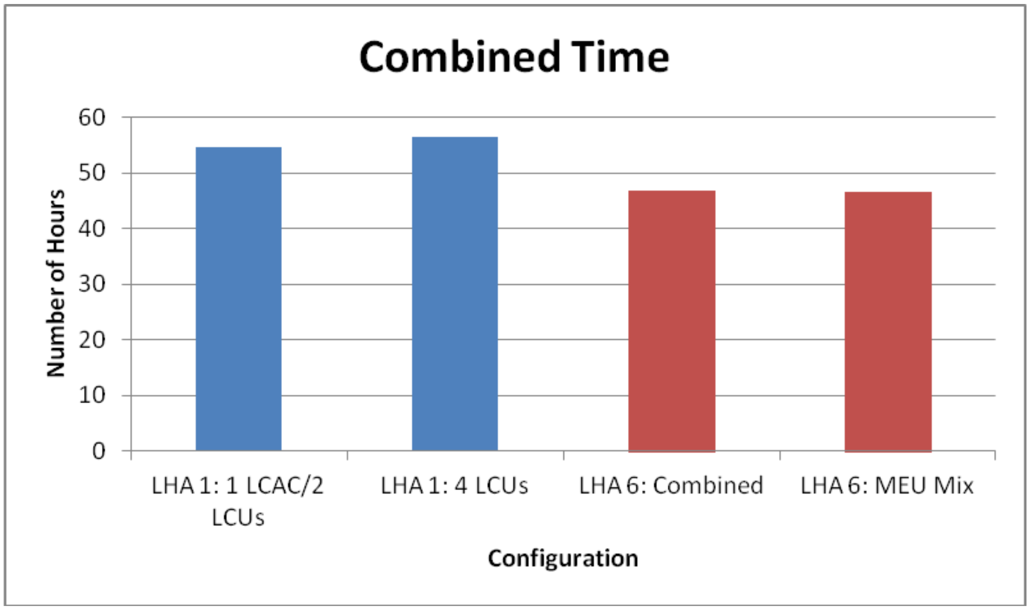

Figure 8. Combined Lift Time.

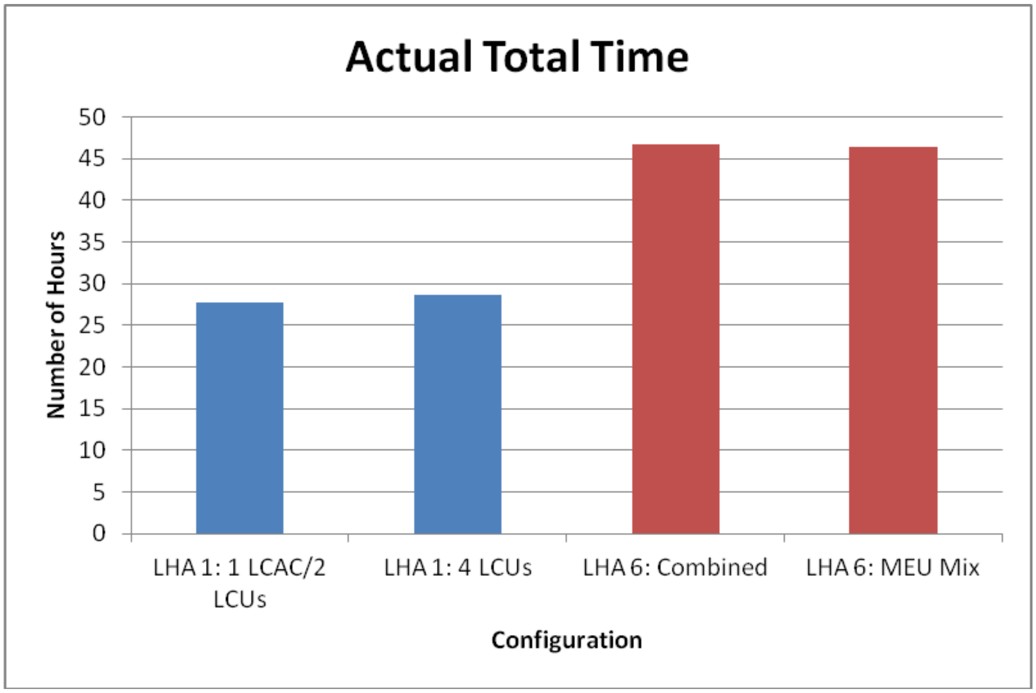

Figure 9. Actual Total Lift Time.

The time/distance problem is an issue that the Navy and Marine Corps struggle with during amphibious operations because it involves several trade-offs. As enemy weapons systems become more sophisticated with greater threat ranges, the stand-off distances off shore increase in order to protect the high value units, or ships. The focus has shifted in recent years to conducting operations "over the horizon" and away from possible enemy detection. While the distance away from land is good for the ships, it becomes an issue for the landing craft and aircraft since they have to travel farther to land the troops ashore. The additional stand-off distance for amphibious ships shifts vulnerability to aircraft flying over the unprotected littorals and places them in more susceptible ports. This is not as big an issue, however, for the faster aircraft but more for the slower landing craft to overcome. The LCAC's speed helps overcome the time/distance problem but sacrifices load tonnage to do so. Adding distance adds more travel time which slows the progress of the landing. Reverting back to the OMFTS and STOM principles, each stresses the importance of maintaining an overwhelming operational tempo yet the time/distance issue works against it. It is easy to then say that an aviation only platform fits into these doctrinal principles. However, the lift time calculations showed that a need for both a simultaneous landing craft and aircraft capability is required to conduct efficient amphibious operations or else the times double. This dilemma will remain an issue for the Navy and Marine Corps Amphibious Commanders to deliberate on to determine the appropriate trade-off of maintaining a fast operational tempo versus amount of protection and risk to the high value units.

C. IMPACTS ON THE AMPHIBIOUS READY GROUP AND AMPHIBIOUS FLEET

The side by side comparison of the two LHA classes revealed major differences in design that affected how amphibious operations are conducted on board and were reflected in the lift equations and example situation previously analyzed. The major changes made to the new LHA class not only affect the shipboard capabilities but the overall capability of the Amphibious Ready Group (ARG) as well. The purpose of the ARG is to transport a landing force to a given location to conduct amphibious operations. The ARG typically consists of three amphibious ships; one amphibious assault ship

(LHA or LHD), one amphibious transport dock (LPD), and one dock landing ship (LSD). The LHA/LHD is the command and control ship for the ARG as the Expeditionary Strike Group (ESG) and/or Amphibious Squadron (PHIBRON) staffs are embarked onboard. Each LPD and LSD class has a well deck that can embark LCACs, LCUs and AAVs and perform the same general amphibious functions as the LHA/LHD but on a smaller scale.

Looking at the three amphibious assault ship classes, LHA *Tarawa*, LHD *Wasp*, and LHA *America*, alone shows that each brings different assets to the ARG and can impact how amphibious operations are conducted. For example, the number of LCAC spots is different on all three with *Tarawa* having one, *Wasp* having three, and *America* of course having zero. Depending on what ship class is in the ARG will impact the time and loading plan for a single amphibious operation. As seen in the time/distance example in the previous section, the number of available assets can drastically add or subtract lift time to the scenario. Table 16 compares the five lift footprints of several classes of ships that can be placed in an ARG. The two classes of amphibious transport docks are the LPD 4 *Austin* class and LPD 17 *San Antonio* class. The two classes of dock landing ships are the LSD 41 *Whidbey Island* class and LSD 49 *Harpers Ferry* class. The LPD classes have the ability to embark aircraft while both LSD classes cannot since they do not have a hangar bay for storage. LSDs do have the ability to conduct flight operations but will mostly be utilized for landing cargo and equipment ashore via landing craft. A major difference to note between the two LSD classes is in amount of cargo cube available. The LSD 49 class is the cargo variant that trades off LCAC spots for more cargo room, which will make a difference in ARG comparisons.

Table 16. Comparison of ARG Ship Lift Footprints.[3]

ARG Comparison					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 1	2,000	25,400	105,900	42	1
LHA 6	1,871	10,328	160,000	45	0
LHD 1	1,871	15,955	113,187	42	3
LPD 4	900	14,000	51,000	4	1
LPD 17	720	23,000	36,000	4	2
LSD 41	454	10,000	5,100	0	4
LSD 49	454	15,500	50,700	0	2

From the ship classes listed in Table 16, 12 different possible ARGs were formed and compared. These comparisons can be seen in Tables 17 through 28. The ARG number itself has no significant importance. ARGs 1 through 4 have LHA 1 as their command ship. ARGs 5 through 8 have LHA 6 as their command ship. ARGs 9 through 12 have LHD 1 as their command ship. The groups are not arranged in any significant order and represent the possible combinations of the command ships with the various LPD and LSD classes.

Table 17. ARG 1 Total Lift Footprints.

ARG 1: LHA 1-LPD 4-LSD 41					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 1	2,000	25,400	105,900	42	1
LPD 4	900	14,000	51,000	4	1
LSD 41	454	10,000	5,100	0	4
Total	3,354	49,400	162,000	46	6

[3] Information gathered from various sources: "Amphibious Assault Ship Well Deck Analysis: Executive Summary" 4, "LHA-1 Tarawa Class," "LHA 6 Information" 4-6, "LHA-6/LHD-1: ESG Lift Comparison" 16, *Marine Corps Reference Publication 3-31B Amphibious Ships and Landing Craft Data Book* 9-14 and 18-23, "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA (R)," "United States Navy Fact File: Amphibious Transport Dock – LPD," "United States Navy Fact File: Dock Landing Ship - LSD."

Table 18. ARG 2 Total Lift Footprints.

ARG 2: LHA 1-LPD 17-LSD 41					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 1	2,000	25,400	105,900	42	1
LPD 17	720	23,000	36,000	4	2
LSD 41	454	10,000	5,100	0	4
Total	3,174	58,400	147,000	46	7

Table 19. ARG 3 Total Lift Footprints.

ARG 3: LHA 1-LPD 4-LSD 49					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 1	2,000	25,400	105,900	42	1
LPD 4	900	14,000	51,000	4	1
LSD 49	454	15,500	50,700	0	2
Total	3,354	54,900	207,600	46	4

Table 20. ARG 4 Total Lift Footprints.

ARG 4: LHA 1-LPD 17-LSD 49					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 1	2,000	25,400	105,900	42	1
LPD 17	720	23,000	36,000	4	2
LSD 49	454	15,500	50,700	0	2
Total	3,174	63,900	192,600	46	5

Table 21. ARG 5 Total Lift Footprints.

ARG 5: LHA 6-LPD 4-LSD 41					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 6	1,871	10,328	160,000	45	0
LPD 4	900	14,000	51,000	4	1
LSD 41	454	10,000	5,100	0	4
Total	3,225	34,328	216,100	49	5

Table 22. ARG 6 Total Lift Footprints.

ARG 6: LHA 6-LPD 17-LSD 41					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 6	1,871	10,328	160,000	45	0
LPD 17	720	23,000	36,000	4	2
LSD 41	454	10,000	5,100	0	4
Total	3,045	43,328	201,100	49	6

Table 23. ARG 7 Total Lift Footprints.

ARG 7: LHA 6-LPD 4-LSD 49					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 6	1,871	10,328	160,000	45	0
LPD 4	900	14,000	51,000	4	1
LSD 49	454	15,500	50,700	0	2
Total	3,225	39,828	261,700	49	3

Table 24. ARG 8 Total Lift Footprints.

ARG 8: LHA 6-LPD 17-LSD 49					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHA 6	1,871	10,328	160,000	45	0
LPD 17	720	23,000	36,000	4	2
LSD 49	454	15,500	50,700	0	2
Total	3,045	48,828	246,700	49	4

Table 25. ARG 9 Total Lift Footprints.

ARG 9: LHD 1-LPD 4-LSD 41					
Ship Class	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
LHD 1	1,871	15,955	113,187	42	3
LPD 4	900	14,000	51,000	4	1
LSD 41	454	10,000	5,100	0	4
Total	3,225	39,955	169,287	46	8

Table 26. ARG 10 Total Lift Footprints.

ARG 10: LHD 1-LPD 17-LSD 41					
Ship Class	**Personnel**	**Vehicle Square (SqFt)**	**Cargo Cube (CuFt)**	**Aircraft (CH-46 Eq)**	**LCAC Spots**
LHD 1	1,871	15,955	113,187	42	3
LPD 17	720	23,000	36,000	4	2
LSD 41	454	10,000	5,100	0	4
Total	3,045	48,955	154,287	46	9

Table 27. ARG 11 Total Lift Footprints.

ARG 11: LHD 1-LPD 4-LSD 49					
Ship Class	**Personnel**	**Vehicle Square (SqFt)**	**Cargo Cube (CuFt)**	**Aircraft (CH-46 Eq)**	**LCAC Spots**
LHD 1	1,871	15,955	113,187	42	3
LPD 4	900	14,000	51,000	4	1
LSD 49	454	15,500	50,700	0	2
Total	3,225	45,455	214,887	46	6

Table 28. ARG 12 Total Lift Footprints.

ARG 12: LHD 1-LPD 17-LSD 49					
Ship Class	**Personnel**	**Vehicle Square (SqFt)**	**Cargo Cube (CuFt)**	**Aircraft (CH-46 Eq)**	**LCAC Spots**
LHD 1	1,871	15,955	113,187	42	3
LPD 17	720	23,000	36,000	4	2
LSD 49	454	15,500	50,700	0	2
Total	3,045	54,455	199,887	46	7

Table 29 shows the comparison of the 12 possible ARGs and lists the totals of each lift footprint that the groups contain. A visual representation of the data in Table 29 is depicted in Figures 10 through 14.

Table 29. ARG Comparison.

ARG Comparison					
ARG #	Personnel	Vehicle Square (SqFt)	Cargo Cube (CuFt)	Aircraft (CH-46 Eq)	LCAC Spots
ARG 1	3,354	49,400	162,000	46	6
ARG 2	3,174	58,400	147,000	46	7
ARG 3	3,354	54,900	207,600	46	4
ARG 4	3,174	63,900	192,600	46	5
ARG 5	3,225	34,328	216,100	49	5
ARG 6	3,045	43,328	201,100	49	6
ARG 7	3,225	39,828	261,700	49	3
ARG 8	3,045	48,828	246,700	49	4
ARG 9	3,225	39,955	169,287	46	8
ARG 10	3,045	48,955	154,287	46	9
ARG 11	3,225	45,455	214,887	46	6
ARG 12	3,045	54,455	199,887	46	7

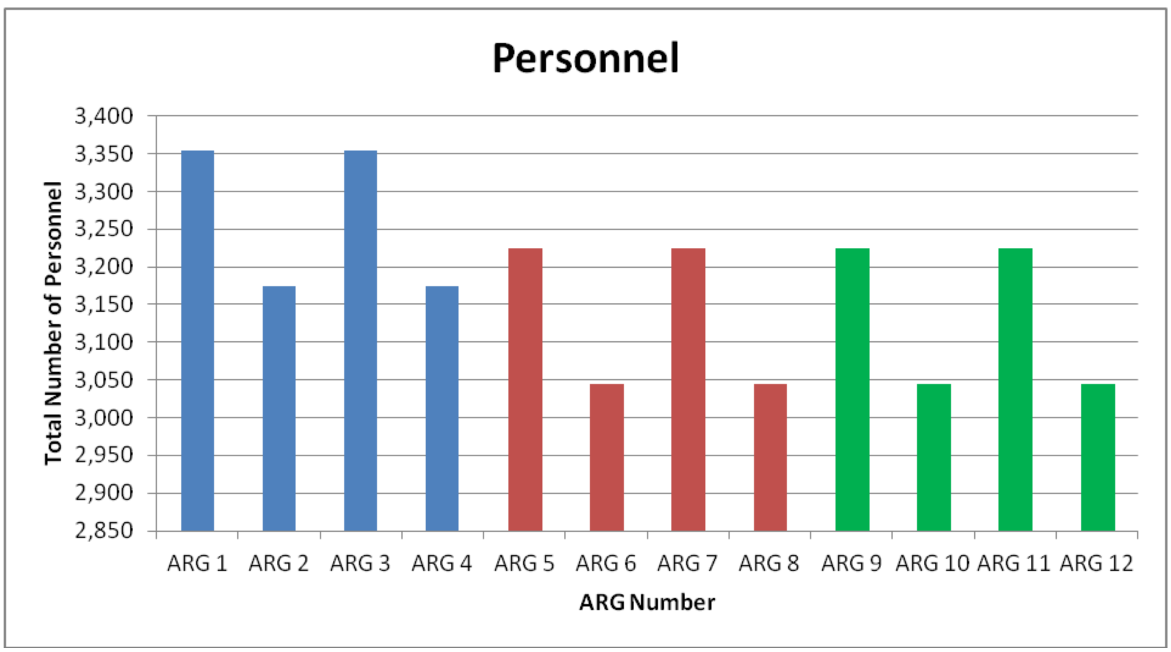

Figure 10. Total Number of Personnel Each ARG Can Embark.

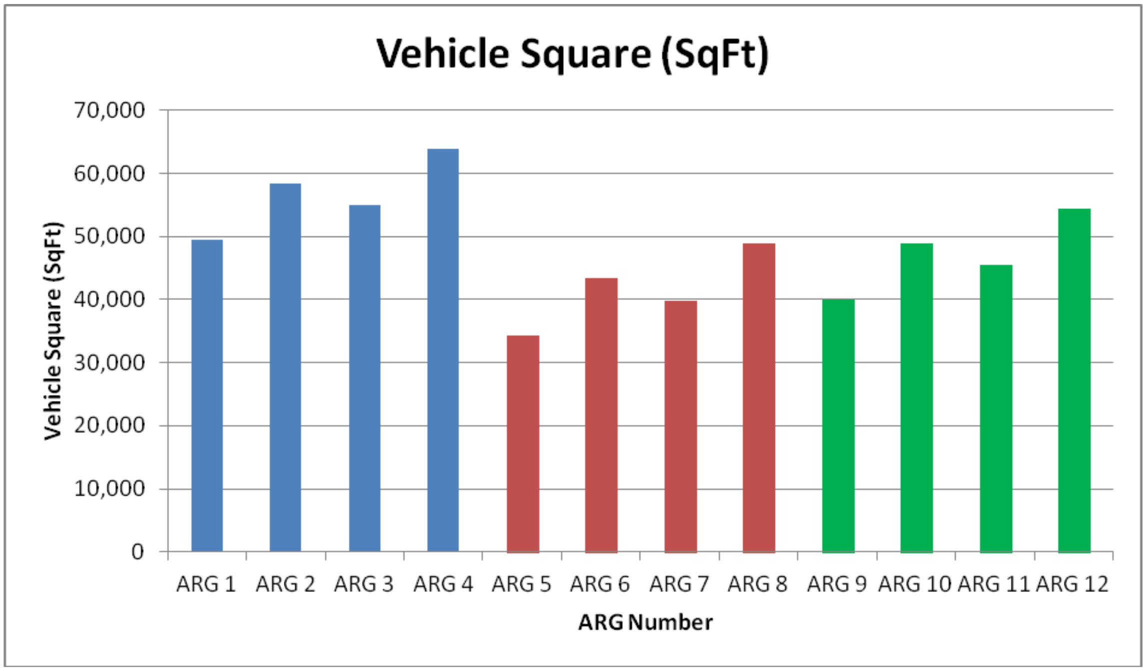

Figure 11. Vehicle Square Footage of Each ARG.

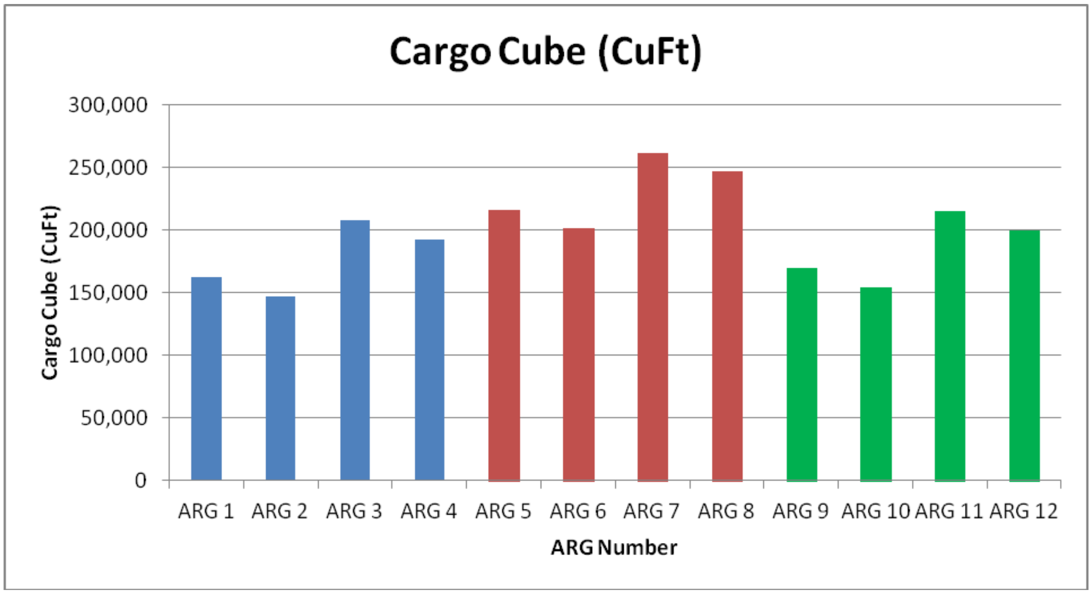

Figure 12. Cargo Cube of Each ARG.

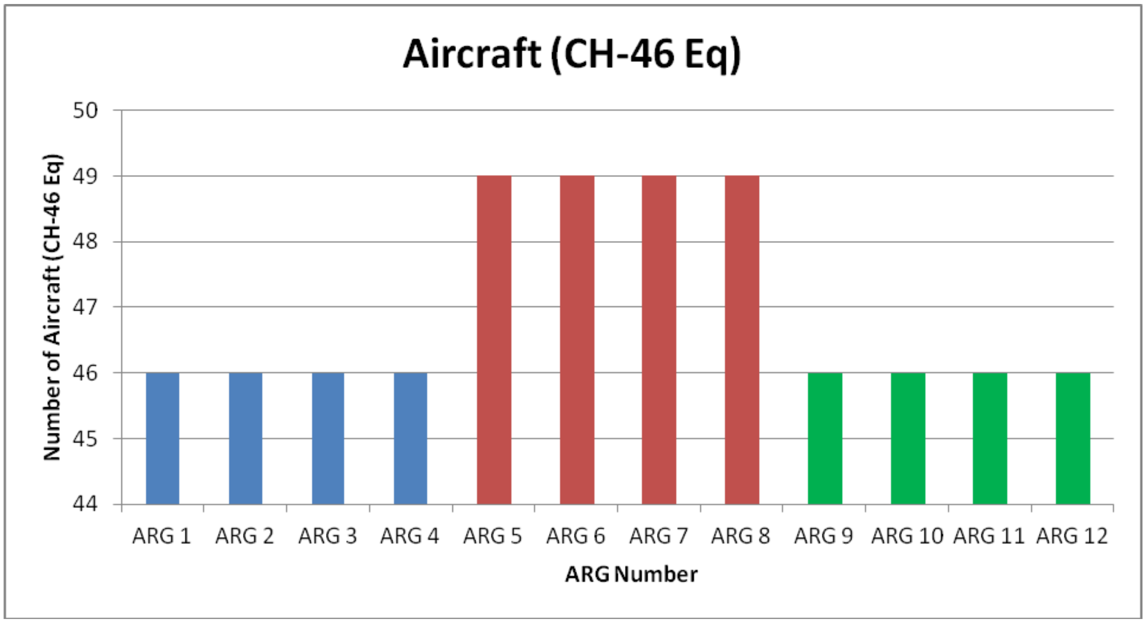

Figure 13. Number of Aircraft Spots (CH-46 Equivalent) on Each ARG.

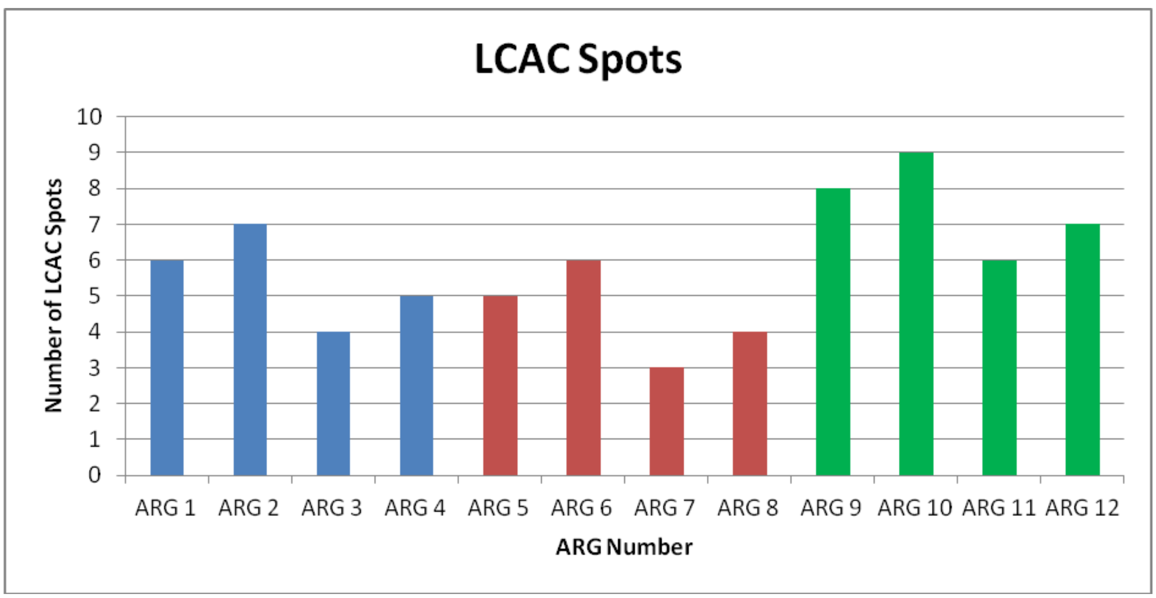

Figure 14. Number of LCAC Spots on Each ARG.

Knowing which amphibious ships make up an ARG is important for both Naval and Marine Corps Commanders to understand because of the differences in lift of each class. As seen from the comparison data of each possible ARG, there is much disparity among the groups' lift footprints. Overall, the LHA 6 and LHD 1 ARGs are most similar, mainly since the new LHA class is modeled after the LHD design. This is counterintuitive since it would make logical sense that the LHA classes would be similar. Subjectively, it is hard to determine which ARG is best as a number of different factors come into play, such as mission type, environment, operational theater, and operational requirements. For example, a mission might require a heavy aircraft presence in which the LHA 6 ARGs would be most effective. On the other hand, a mission might require a large amphibious landing in which the LHD 1 or LHA 1 ARGs would be the better choice for the operation over the LHA 6 ARGs. With the frequent changes in amphibious operational requirements, the Navy should ultimately decide on the most flexible option since it will have the ability to accomplish a wider range of missions and objectives. From a quantitative perspective, comparing the ARGs becomes a much easier task.

Looking at the personnel lift footprint, all of the ARGs meet the requirement of embarking and transporting a full MEU. The average number of Marines in a single MEU is about 2,200 ("United States Marine Corps: Roles & Missions, Organization, Capabilities, Employment Considerations, Concepts, Programs, & Current Issues" 27). Each ARG has room to spare as they all can fit well over 3,000 personnel across each of the three ships. ARGs 6, 8, 10, and 12 have the lowest number totaling 3,045 personnel as the LPD 17 class holds roughly 200 less troops than the LPD 4 class. The LHA 1 makes up for this loss in ARGs 2 and 4, which still shows a drop in number but remains above 3,100 personnel. ARGs 1 and 3 hold the highest number of personnel once again attributing to the extra space for troops on board LHA 1. Overall, all 12 ARGs meet the personnel requirement as a MEU will typically consist of less than 3,000 troops, however, getting the Marines to the amphibious objective area is not even half the battle.

The LHA 1 ARGs hold a clear advantage in amount of vehicle square footage. ARGs 1 through 4 have the most space for vehicles and dominate in this category. Each of the remaining ARGs has less than 50,000 square feet for vehicle stowage, except one, ARG 12. Typically the MEU will require about 160 vehicles, which will range from 45,000 to 55,000 in vehicle square feet ("United States Marine Corps: Roles & Missions, Organization, Capabilities, Employment Considerations, Concepts, Programs, & Current

Issues" 27). This becomes an issue for ARGs 5 through 12 as vehicles will be left on the pier because they cannot fit in storage on the ships. Looking ahead ten years to future MEU lift requirements, the estimated total amount of square footage needed is almost 90,000, well above what any of the current ARGs can carry ("Amphibious Assault Ship Well Deck Analysis: Executive Summary" 5). This is currently a red flag issue that the Marine Corps is assessing to determine how much of an impact it will have on MEU capabilities. It will obviously have some kind of effect, most likely decreasing the amount of capability the ground combat element will have, whether its mobility, firepower, or general output power. Overall, the LHA 1 ARGs meet the current vehicle square foot lift requirements. However, in the near future none of the current 12 possible ARGs will be able to lift the desired amount of vehicles the MEU intends to operate with, leaving a gap in the current ARG make up.

Relating to vehicle square footage is amount of cargo cube each ARG can carry. The LHA 6 ARGs have the clear advantage in this category as the removal of the well deck and aviation design expansion in the *America* class opened up more space for cargo storage. ARG 7 has the greatest amount of cargo cube available, towering at 260,000 cubic feet, as each ship in the group has the greatest amount of cargo room in their respective classes. ARG 2 has the lowest amount of cargo space available, falling below 150,000 cubic feet. Amount of cargo cube available is important because it plays a major role in the MEU 15 day sustainment requirement and to the extent of how many humanitarian supplies can be carried in a disaster relief effort. Future MEU cargo lift requirements estimate that 170,000 cubic feet of space will be needed to fit all the necessary items ("Amphibious Assault Ship Well Deck Analysis: Executive Summary" 5); leaving a gap for ARGs 1, 2, 9 and 10.

The LHA 6 ARGs also have a clear cut advantage in number of aircraft spots only because the *America* class has three additional spots. The magnitude of this advantage is not very significant because there are only three additional spots available in these ARGs. LHA 6 is essentially built for the "aircraft of the future," like the MV-22 and F-35;

however, each ARG will be able to embark the new aircraft just in a slightly more limited capacity. Overall, every ARG will be able to meet current and future aircraft requirements.

Lastly, the number of LCAC spots in each ARG varies from three to nine among all the groups. As seen in the lift equations and time/distance example, the amount of landing craft utilized in amphibious operations can make a big difference. Current and future MEU lift requirements dictate that six or more LCAC spots are needed to effectively conduct amphibious operations ("Amphibious Assault Ship Well Deck Analysis: Executive Summary" 5). Not meeting this requirement are ARGs 3, 4, 5, 7, and 8. All of the LHD 1 ARGs fit this category best, and, even though ARGs 3 and 4 fall under the requirement, each still have a well deck and other means (LCUs and AAVs) to offload and land troops and their equipment ashore. Only one of the LHA 6 ARGs meets this requirement: ARG 6 with six LCAC spots between the LPD and LSD. Overall, the LHD 1 ARGs meet this requirement effectively.

The data suggest that there is no right or wrong ARG solution for what the Navy and Marine Corps currently have in their arsenal. Each possible ARG has its advantages and disadvantages when it comes to lift capabilities. All of the lift footprints illustrate a tough trade-off to consider in the shipbuilding industry: a given amount of space versus where to put everything and how much of that everything will meet the requirements. The LHA 6 model sacrificed LCAC spots and a major capability for cargo cube and greater aviation ability. LHA 1 has a greater amount of vehicle square footage but sacrifices additional hangar bay space for aircraft in doing so. This trade-off holds true in a group of ships, as demonstrated through the ARG comparisons. Each of the combination of ships have unique lift footprints that may give one ARG a great advantage in a particular area of amphibious warfare but may seriously lack in another. The trade-offs in lift footprints encountered among each ARG is not necessarily a bad thing. Each mission is different and may require more or less of a capability. This allows the ARG to be tailored to every mission as it gives the Navy and Marine Corps more options to choose from. Consequently, the possible ARGs cannot be used in a "plug and play" sense with the MEU because each has different lift configuration to consider.

Additional planning for the commanders is necessary to properly address the different lift footprints each ARG offers in order to successfully deploy and accomplish the mission.

Further studies conducted by the Navy and Marine Corps Operational Test and Evaluation Activities on ESG lift comparisons found similar results. One study in particular did a comparative analysis of a LHA 6 ARG versus a LHD 1 ARG to assess potential operational impacts. An operational assessment of the new *America* class LHA was performed unusually early in the life cycle the summer of 2005 because the Analysis of Alternatives never examined this new amphibious configuration. The purpose of this study was to determine the impacts of lost capabilities associated with an undefined CLOP, or capability/cargo left on the pier ("LHA-6/LHD-1: ESG Lift Comparison" 3). The two ARGs compared were LHD 1 – LPD 17 – LSD 41 and LHA 6 – LPD 17 – LSD 41. The parameters established by the Operational Test and Evaluation Activities included a year 2015 MEU force list of personnel and amount of equipment, vehicles, and cargo that the MEU would require. A load plan was developed for each MEU that incorporated four principles: 1) employ current MEU stowage techniques, 2) maximize available square feet to maintain operational flexibility, 3) maximize mobile landing of vehicles, and 4) minimize cross-deck requirements ("LHA-6/LHD-1: ESG Lift Comparison" 4). From the list of parameters, the Operational Test and Evaluation Activities established an equipment density list (EDL) which depicts an inventory of equipment and amount for each element of the MEU. The EDL established for the study can be seen in Appendix C ("LHA-6/LHD-1: ESG Lift Comparison" 9–11). The comparison of the load results show that an LHD ARG is fully capable of meeting the current MEU requirements while the LHA ARG falls short of the mark. The results are summarized in Tables 30 and 31.

Even with double stacking cargo containers and using a flight deck spot on the LSD 41 for stowage, the LHA 6 ARG still cannot meet the MEU lift requirements. A substantial amount of items, 96, are left on the pier, which decreases the capability of the MEU and jeopardizes their 15 day sustainment requirement. Many of the CLOP items summarized in the study included several vehicles, replacement parts, and supplies, which will negatively impact the MEU's mission and degrade their sustainment capability ("LHA-6/LHD-1: ESG Lift Comparison" 17–18). Interesting to note is the ARGs that the Operational Test and Evaluation Activities chose to compare. As the older LHA *Tarawa* class ships are being decommissioned out of service, the LHD is currently the dominant amphibious assault ship in the fleet. The LPD 17 class was chosen as they are newer and replacing the older LPD 4 class ships. The Operational Test and Evaluation Activities elected to go with more LCAC spots over cargo cube and storage space as they chose to use LSD 41 over the cargo variant LSD 49 class. With the required number of LCAC spots at 6, the only combination of ships that worked with the LHA 6 was LPD 17 and LSD 41, which was previously discussed in the possible 12 ARG comparative analysis. Overall this study shows that the new LHA ARG will not meet all the MEU lift requirements and suggests that possible alternatives are needed to address this capability gap.

Table 30. LHD 1 ARG (From "LHA-6/LHD-1: ESG Lift Comparison" 16).

LHD 1 ARG					
Ship	**LHD 1**	**LPD 17**	**LSD 41**	**EDL Loaded**	**CLOP**
Square Feet	19,145	22,356	19,473	60,974	0
Items	233	218	158	609	0
Personnel	1,325	567	393	2,285	N/A

Table 31. LHA 6 ARG (From "LHA-6/LHD-1: ESG Lift Comparison" 16).

LHA 6 ARG					
Ship	**LHA 6**	**LPD 17**	**LSD 41**	**EDL Loaded**	**CLOP**
Square Feet	11,115*	20,904	19,346	51,365	9,608
Items	154	199	160	513	96
Personnel	1,218	657	392	2,267	N/A

*Includes 40 double stacked QUADCONs (1,547 sqft), actual LHA 6 square feet on deck is 10,328

As shown through the ARG comparative analysis data and evidence, there will be impacts to amphibious mission planning, operational capabilities, and amphibious landing execution due to the various lift configurations in changing shipboard environments. The primary mission, the reason why amphibious ships exist, is to transport Marines and their equipment ashore by the most effective means possible. Eliminating a major capability in the largest ship of the ARG will negatively impact how missions are planned and executed. Because of the changes in amphibious design, capabilities in the form of vehicles, cargo, supplies, and even personnel will be left behind on the pier which adds risk that may jeopardize the success of the mission. Understandably there are several trade-offs made from ship to ship and from ARG to ARG. As design changes are made in subsequent ship classes, it ultimately changes the capabilities and make up of an ARG, resulting in an inability for commanders to "plug and play" each ARG into operations and missions. Regardless of the ARG type, joint theater commanders need to know what assets the amphibious forces have in order to deploy them the most effectively.

Adjusting the capabilities gap that the LHA 6 ARGs will have may be a daunting task for the Navy and Marine Corps to accomplish. Two possible solutions are to either add an additional amphibious ship to the ARG or have the LHA 6 operate independently. Adding an additional LPD or LSD to the ARG would increase the lift footprints enough to meet the MEU lift requirements. However, it would cause other issues for the amphibious fleet, such as ship maintenance and training schedule issues and altering other ARGs. Shifting the ARG mentality would at first disrupt LPD and LSD schedules that could quickly escalate to major problems if required maintenance cannot be performed on time leading to possible failures at sea. Second, other ARGs in the fleet would be affected as one of the ships from the group would be pulled away to the LHA 6 ARG, rendering the group ineffective. Fewer ARGs in the fleet may mean a decrease in projection of power missions and available assets for naval requirements. Each dilemma could be overcome but would require a greater amount of trade-offs with additional risk. The LHA 6 might better suit the amphibious fleet if it steamed independently with its own missions as the LHD *Wasp* class ships took the lead in each ARG. As seen in the single ship comparison of the LHAs, the *America* class would not be an effective means to perform independent amphibious landings and would most likely take on an aircraft carrier role in the fleet. While this seems the most likely role for LHA 6, it does defeat the purpose of building a replacement LHA amphibious assault ship in the first place. The *America* class was intended to be the center of the ESG/ARG and be the dominate ship in the amphibious fleet. This certainly will not be the case as the ship lacks the command and control, lift, and transport capabilities required for amphibious operations. Enacting either of the solutions will cause a major shift in traditional amphibious practices and force changes across the entire amphibious fleet.

The decision to make a major cultural shift onboard what is supposed to be the future ship of the amphibious Navy was done so in haste and prematurely without proper analysis. The entire purpose of having a standardized acquisition and decision making process is to ensure hasty, irrational decisions are not made at the expense of the warfighter. For instance, the LHA (R) Analysis of Alternatives study, a crucial tool in acquisition decision making, did not even consider the possibility of having an amphibious ship without a well deck because it was impractical do to so and did not fulfill the key performance parameters dictated by the Navy. Each recommended design had both the facilities and space to accommodate the extra aviation assets and maintain a well deck. In the blink of an eye, however, the Navy shifted its rudder and forced the Marine Corps into an undesired culture change in amphibious operations without considering the impacts it would have on the naval service.

V. CONCLUSION

A. RESEARCH CONCLUSIONS

The ability of the United States Navy and Marine Corps to conduct amphibious operations throughout the world is a vital asset that no other country can rival. The shift in future amphibious ship design, however, has threatened the integrity of this asset by degrading the capabilities that the warfighter constantly relies upon. The removal of the well deck and loss of crucial lift capacities in the new LHA (R) *America* class amphibious assault ships have presented a major dilemma for the Navy and Marine Corps as future assets will not be able to fully integrate with current, proven doctrine, tactics, techniques, and procedures.

Amphibious warfare doctrine along with a detailed analysis of current and future capabilities were presented in this thesis to determine how a shift in amphibious warfare design decisions would affect Navy and Marine Corps capabilities. It was determined that the loss of the well deck would wreak havoc on the effectiveness and efficiency of amphibious operations and seriously hinder the warfighters' ability to accomplish missions at a high level of proficiency. The *America* class LHAs will not be an effective contributor during any combat or humanitarian operations that involve some type of amphibious landing because it will be unable to meet all of the lift requirements of a landing force. Because it is an aviation only platform, the new LHAs will be forced to leave crucial capabilities on the pier since the helicopters on board have much greater weight and lift constraints and will not be able to carry certain Marine equipment and vehicles. Additionally it was shown that the *America* class LHAs will have a drastic increase in the amount of time it would take to conduct an amphibious landing ashore due to the fact that it only has aircraft to lift both personnel and equipment. Current amphibious assault ships have a clear advantage in this category because they have the dual flight deck and well deck capability that allows for simultaneous operation of aircraft and landing craft to land a force ashore in half the amount of time as the future LHA. The shift in amphibious design will also make "accessing the inaccessible" twice as hard for the Navy and Marine Corps to accomplish, especially during humanitarian aid and assistance missions, as the ship's performance capabilities have literally been cut in half.

Making extreme changes and design decisions to the largest asset of the amphibious fleet has also violated the traditional, accepted doctrine that has been practiced and trained to perfection over the past several decades. The forced culture shift of operating without a well deck capability has taken Sailors and Marines by surprise as they are not prepared to continue to operate using the same amphibious warfare principles. That being the case, the *America* class LHAs will most likely act and be treated as a light aircraft carrier instead of an amphibious assault ship. This violates the entire purpose of why the new ship was created in the first place: to displace the older LHA *Tarawa* class and be the center of the Expeditionary Strike Group/Amphibious Ready Group. The new LHAs will not be able to do this if it does not act like an amphibious assault ship and thus repeating the vicious cycle of contradiction.

The secondary research question this thesis posed was to determine how design decisions are made in the military. The Department of Defense acquisition's life cycle was examined and analyzed to answer this question. It was found that decisions to acquire new programs are made at a high level of authority, residing at the Joint Chiefs of Staff positions. Using the Joint Capabilities Integration and Development System, the Joint Chiefs and their staffs essentially conduct a capabilities gap analysis and determine what programs to further pursue. In the case of the LHA (R) Program, a need arose to replace the aging amphibious assault ships in the fleet. Design decisions for the new LHA began following program inception at the highest levels of the Department of the Navy along with the shipbuilders and contract designers from Northrop Grumman. Examining the acquisition's process as it applied to the LHA (R) Program revealed that it can be just as complex as it sounds with many hands "stirring the pot" to further complicate matters. Design decisions have as much to do with requirements, performance, and intended purpose as politics, cost, and personal agendas. The LHA (R) Program was unfortunately susceptible to these factors which caused the decision making process to break down and almost fall apart.

B. RECOMMENDATIONS

Based on the facts and evidence provided along with the current and future MEU lift requirements, it was determined that the best recommended amphibious model for the Navy and Marine Corps would be to have a large amphibious assault ship with both a well deck and flight deck capability for simultaneous operations. As the Navy and Marine Corps work together it is vital that their equipment work mutually with one another. The MEU is a flexible and powerful force because of the balance it maintains within its organization that relies on aviation and ground assets to accomplish the mission. Therefore, the amphibious ship model should maintain that balance of force and have both a well deck and flight deck in the design. If the amphibious requirements remain in place or even increase in the future as expected, both assets will be a vital necessity in order to perform operations at the same high level of expectations. Whether it is a combat or humanitarian mission, the dual aircraft and landing capability along with a substantial medical facility on board that can accommodate a mass casualty situation will be required to accomplish the objective that the amphibious fleet is so accustomed to doing. As the focus of the United States' military strategy is on accessing the inaccessible, the question is how to accomplish this task. The answer is using the versatile and unique amphibious assets comprised of air and surface forces.

The most unique of the amphibious assets is the well deck because it expands on the amount of capabilities that the landing force has and can use. With the shifting focus to "over-the-horizon" amphibious landings, the best well deck configuration is to have three LCAC spots as seen in the LHD *Wasp* class. Three LCAC spots are desired so that the amphibious ship can be matched up with any combination of LPD or LSD and still maintain the required six or more total LCAC spots within the ARG. As seen in the amphibious doctrine, the Marine Corps favors a faster landing craft with an over the horizon capability in order to maintain a favorable operational tempo to overwhelm the enemy at the beach. While it may take additional LCAC loads to transport all the equipment to the objective area, its speed allows for a better simultaneous push to the beach in conjunction with the aircraft and helps to eliminate the undesired operational pause. The LCU is still a valuable asset and will also be an available craft that the proposed amphibious model ship can embark. Having a well deck onboard the ship will also allow for the embarkation of AAVs for opposed landings as well, increasing the combat capability of the fleet.

The concern for space for the new aviation assets onboard an amphibious assault ship is the main reason why the well deck was eliminated. While the dollar cost is understandably an issue, the warfighter should not have to suffer the performance cost and make risky sacrifices when it comes to required capabilities. In order to accommodate the MV-22 *Osprey* and the F-35 Joint Strike Fighter, it is recommended that the amphibious assault ship be expanded in length, width, and height, particularly in the hangar bay. Expanding the size of the ship will allow for the additional space needed for maintenance and stowage of the aircraft while keeping a large medical facility and well deck on board. To gain more room on the flight deck, space can be traded-off on the island that extends up from the deck itself. Two previous classes of amphibious assault ships have made the dual well deck – flight deck coexistence work, proving that this concept can be accomplished. The proposed overall expansion of the amphibious assault ship would also add to the amount of rack space available for the embarked troops. This is an added benefit in the personnel lift footprint category as valuable assets will not be left on the pier.

Tackling the vehicle square footage and cargo cube footprints is a difficult task that even the Navy and Marine Corps are currently struggling with. Basically it again all comes down to space on board the ship. Expanding the overall size of the ship will relieve some of the tension and leave fewer items behind on the pier. For current requirements, the best model to follow is again the LHD *Wasp* class as it has been proven that an LHD ARG can lift a MEU and their equipment. To accommodate future MEU lift requirements it is recommended that the Navy invest in more Maritime Prepositioning Force ships to supplement the ARGs. Another possible solution involves investing in more amphibious ships that can be added to the ARGs making the group even at four ships instead of three. Telling the Marines or the President they “can’t have any more toys” is also one more possibility but not highly recommended.

Therefore, the recommended lift footprint requirements that the amphibious model should meet include:

- Personnel: Between 2,000 and 2,100 embarked troops.
- Vehicle Square Footage: Between 27,000 and 30,000 square feet.
- Cargo Cube: Between 120,000 and 130,000 cubic feet.
- Aircraft Spots: Between 46 and 49 CH-46 equivalent spots (full size flight deck).
- LCAC Spots: 3 (full size well deck).

Each recommended lift footprint expands on the current LHA and LHD amphibious assault ships. These lift footprints will meet the current and expected future lift requirements for the landing force, except for future vehicle square footage. This issue is currently being examined by the Navy and Marine Corps for the purpose of developing alternatives in vehicle transport and stowage. Two possible solutions for this problem involve adding a fourth ship to the Amphibious Ready Group and/or further development and construction of a Maritime Prepositioning Force.

In summary, the recommended proposed amphibious model will have both a flight deck and well deck that can accommodate the current landing craft and current and future aircraft. It will be an extended, larger version of current amphibious assault ships with a substantial medical facility and troop berthing space. The expansion of the ship will allow for enough required vehicle and cargo space to carry all MEU equipment. Additional Maritime Prepositioning Ships may be required in the future if MEU lift requirements expand beyond ARG carrying capability.

C. RECOMMENDATIONS FOR FUTURE WORK

Once the *America* Class LHAs are built and fully integrated and established in the amphibious fleet, a continuation of this thesis research can be conducted to actually see how the ship is being utilized and how it affects Navy and Marine Corps capabilities and missions. The expected data of LHA 6 would then be replaced by actual data in the calculations. Physical observations on lift and affects on the MEU could be observed first hand. A specific angle to observe and examine is the utilization of vehicle square footage and cargo cube on board LHA 6 as it would be interesting to note what exactly the space is being used for (additional aircraft parts or MEU equipment/vehicles/supplies/cargo). Further research could also supplement the Navy and Marine Corps' current analysis on future expected vehicle transport and stowage problems to development alternatives to meet the requirements.

Another topic for future research and consideration is to develop doctrine and guiding principles for the LHA *America* class amphibious assault ships. This thesis showed that the shift in design violated the current amphibious warfare doctrine. Eliminating the well deck certainly changes the shipboard environment and situation for the warfighter. Establishing doctrine for the new asset will be the first step in accepting a new amphibious fighting machine without its standard capabilities.

Lastly, future work and analysis can be developed further on the many factors that affect the amphibious lift equations and time/distance problem to the beach. For example, certain weather and sea states will affect what landing craft and aircraft assets are available for an amphibious landing as each has their limitations. A chart can be developed to determine what capabilities will be affected during specific weather events and sea states that will then add or subtract to the overall time of the amphibious landing.

APPENDIX A: CURRENT AMPHIBIOUS CAPABILITIES

Table 32. LHA *Tarawa* Class Specifications.[4]

LHA *Tarawa* Class Amphibious Assault Ships	
Shipbuilder	Ingalls Shipbuilding
Propulsion	Steam turbines, 2 boilers, 2 shafts, 70,000 horsepower
Length	820 feet
Beam	106 feet
Displacement	39,400 tons
Max Speed	24 knots
Max Range	10,000 nautical miles
Fuel	Diesel Marine, 5,900 tons
Crew	1,000 Sailors
Landing Force	2,000 Marines
Aircraft Spots	42 (expressed as CH-46 equivalents)
Landing Craft	4 LCUs or 2 LCUs and 1 LCAC
Vehicle Storage Area	25,400 square feet
Cargo Storage Area	105,900 cubic feet

Figure 15. LHA *Tarawa* Class, *USS Tarawa*, LHA-1 (From "Avalonn.com Presents Letter from the front lines").

4 Information gathered from various sources: "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)," "LHA-1 Tarawa Class," and *A CBO Study: The Future of the Navy's Amphibious and Maritime Prepositioning Forces* 4.

Table 33. LCAC Specifications (After "United States Navy Fact File: Landing Craft, Air Cushioned" and Textron Marine & Land Systems).

Landing Craft Air Cushioned (LCAC)	
Builder	Textron Marine and Land Systems
Propulsion	4 gas turbine engines, 2 shrouded reversible pitch airscrews, 16,000 horsepower
Length	87 feet 11 inches
Beam	47 feet
Displacement	87 tons lightly loaded, 170–182 tons with a full load
Max speed	40–50 knots
Range	200 nautical miles at 40 knots, 300 nautical miles at 35 knots
Crew	5 enlisted personnel (craftmaster, engineer, navigator, loadmaster, deck engineer)

Figure 16. LCAC (From "Post Card Gallery #2: Landing Craft Air Cushion (LCAC) ACU-4").

Table 34. LCU Specifications (After "United States Navy Fact File: Landing Craft, Mechanized and Utility (LCM/LCU)").

Landing Craft Utility (LCU)	
Builder	Various shipbuilders of the 1970s
Propulsion	2 diesel engines, 2 shafts, 680 horsepower
Length	134.9 feet
Beam	29 feet
Displacement	200 tons lightly loaded, 375 tons with a full load
Max speed	11 knots
Range	1,200 nautical miles at 8 knots
Crew	14 personnel

Figure 17. LCU (From "Landing Craft Utility (LCU): Overview").

Table 35. AAV Specifications.[5]

5 Information gathered from various sources: "AAV-7 Amphibious Assault Vehicle," "PMAAVS Program Brief" 3, LVTP7 Landing Vehicle, Tracked AAVP7A1 Assault Amphibian Vehicle Personnel," and "AAVs."

Amphibious Assault Vehicles (AAV)	
Builder	FMC Corporation
Propulsion	single diesel engine, 400 horsepower
Length	27 feet
Width	11 feet
Height	11 feet
Max speed	7 knots, cruising speed of 5 knots in water
Range	in water 7 hours at 5 knots, on land 300 miles at 21 knots
Crew	3 Marines (Rear Crewman, Driver, and Trac Commander)

Figure 18. AAV (From "LVTP7 Landing Vehicle, Tracked AAVP7A1 Assault Amphibian Vehicle Personnel").

APPENDIX B: FUTURE AMPHIBIOUS CAPABILITIES

Table 36. LHA *America* Class Specifications.[6]

LHA *America* Class	
Shipbuilder	Northrop Grumman Ship Systems
Propulsion	2 gas turbine engines, 2 shafts, 70,000 horsepower, 2 5,000 horsepower auxiliary motors
Length	844 feet
Beam	106 feet
Displacement	45,000 tons
Max Speed	22 knots
Max Range	10,000 nautical miles
Fuel	Diesel Marine, 6,000 tons
Crew	1,204 Sailors
Landing Force	1,871 Marines
Aircraft Spots	45 (expressed as CH-46 equivalents)
Landing Craft	0 craft, no well deck
Vehicle Storage Area	10,328 square feet
Cargo Storage Area	160,000 cubic feet

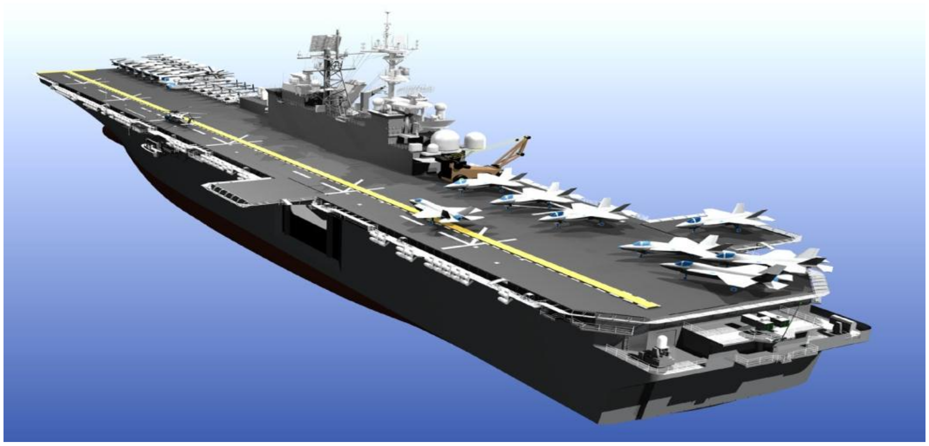

Figure 19. *USS America*, LHA-6 (From "LHA-6/LHD-1: ESG Lift Comparison").

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6 Information gathered from various sources: "PEO Ships Amphibious Assault Ships (LHA 6): Program Summary," "United States Navy Fact File: Amphibious Assault Ships LHA/LHD/LHA(R)," and "LHA 6 Information" 4–6.

Table 37. *Osprey* Specifications.[7]

MV-22 *Osprey*	
Builder	Bell-Boeing
Engines	Rolls-Royce Liberty, 7,000 kilowatts
Max Cruising Speed	241–257 knots
Range/Aft Sponson Fuel Tank	Land-assault missions 242 nm, pre-assault raid 267 nm
Range/Wing Fuel Tanks	Land-assault missions 233 nm, pre-assault raid 306 nm
Cargo Hook Lift	Single 10,000 pounds, dual 15,000 pounds
Personnel Carrying Capacity	24 combat ready Marines

Figure 20. V-22 *Osprey* (From "BellBoeing V-22 Osprey").

7 Information gathered from various sources: "MV-22 Osprey: Speed, Range and Vertical Flight," Bolkcom Summary and CRS-2, "United States Navy Fact File: V-22A Osprey tilt rotor aircraft," and "V22 Characteristics."

Table 38. F-35 Specifications.[8]

F-35 Joint Strike Fighter	
Builder	Lockheed Martin
Engines	F135-PW-100, 40,000 pounds of max thrust
Length	51.2 feet
Height	14.3 feet
Wingspan	35 feet
Weight	Empty 15,000 pounds, max weight 60,000 pounds
Max Speed	1.6 mach
Range	Combat radius greater than 450 nm, max range greater than 900 nm
Weapons Payload	15,000 pounds; 2 air-air missiles, 2 1,000 pound guided bombs
Lift Capability	0, strike only

Figure 21. F-35 Joint Strike Fighter (From "F-35B STOVL Variant: F-35 Lightning II").

[8] Information gathered from various sources: "Introduction: F-35," "F-35B Short Takeoff/Vertical Landing Variant," and "F-35B STOVL Variant: F-35 Lightning II."

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APPENDIX C: EQUIPMENT DENSITY LIST

TAMCN	NOMENCLATURE	CE	GCE	ACE	LCE	NSE	ESG TOTAL
A0818	LMST SUPER HF TRIBAND ADV RANGE EXT TERM	1	0	0	0	0	**1**
A0966	MEWSS	1	0	0	0	0	**1**
A2600	TRACKING NETWORK, COMPOSITE (PLANNED)	0	0	1	0	0	**1**
A3232	TRANSPORT TACSATCOM (SMART-T) AN/TSC154	1	0	0	0	0	**1**
AX001	MRC JTRS	10	13	3	12	0	**38**
AX002	MRC IMPROVED TROPO	1	0	0	0	0	**1**
AX003	MAGTF BORDER GATEWAY (JTF HMMWV)	1	0	0	0	0	**1**
AX004	DTC MSC (HMMWV)	1	0	0	0	0	**1**
AX101	MRRS (RADAR) HMMWV	0	0	1	0	0	**1**
AX108	SDS FOR CA2CS HMMWV	0	0	1	0	0	**1**
AX109	PDS FOR CA2CS HMMWV	0	0	1	0	0	**1**
AX110	CS FOR CA2CS HMMWV	0	0	1	0	0	**1**
AX111	IS FOR CA2CS HMMWV	0	0	1	0	0	**1**
B0446	CRANE, RT, HYDRAULIC, LIGHT (DET, ENGR)	0	0	0	1	0	**1**
B0589	EXCAVATOR, COMBAT (ACE)	0	1	0	0	0	**1**
B1298	LINE CHARGE LAUNCH KIT, TRLR MTD	0	2	0	0	0	**2**
B2464	TRACTOR, FULL TRACK W/MULTI-PUR BUCKET	0	0	0	1	0	**1**
B2482	TRACTOR, ALL WHEEL DRIVE W/ATTACHMENTS	0	1	0	0	0	**1**
B2561	TRK, FORKLIFT, 11K	0	0	1	2	0	**3**
B2565	ENGINEER EQUIPMENT TRLR	0	0	0	1	0	**1**
B2566	TRUCK,FORKLIFT ROUGH TERRAIN 5000 LB	0	0	1	1	0	**2**

TAMCN	NOMENCLATURE	CE	GCE	ACE	LCE	NSE	ESG TOTAL
B2567	TRACTOR, RT, ARTICULATED STEER	0	0	0	4	0	**4**
B2685	WELDER, TRAILER	0	0	0	1	0	**1**
C4433	CONTAINER, QUADRUPLE	36	50	40	108	7	**241**
C7033	TRUCK, CONTACT, HMMWV	0	0	0	3	0	**3**
CXXXX	Shelter, Shop 20 FT	0	0	0	0	2	**2**
D0080	CHASSIS, TRLR, GEN PUR, 3 1/2 TON, 2-WHL	0	0	0	3	0	**3**
D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	1	4	1	3	0	**9**
D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	0	12	0	14	1	**27**
D02X1	TRUCK, CARGO, MKR-18	0	0	0	6	0	**6**
D02X2	TRUCK, WRECKER, MKR-15	0	0	0	1	0	**1**
D0850	TRLR, CARGO, 3/4T, 2-WHL	9	9	2	11	2	**33**
D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	0	0	0	9	0	**9**
D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	0	0	0	8	1	**9**
D1001	TRK AMB, 2 LITTER ARMD, 1 1/4 TON HMMWV	0	2	0	2	0	**4**
D1002	TRK AMB, 2 LITTER, SOFT, 1 1/4 TON HMMWV	0	3	0	0	0	**3**
D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	0	1	0	1	0	**2**
D1082	TRUCK, FIREFIGHTING, 1 1/4T, 4X4	0	0	1	0	0	**1**
D1125	TRUCK,UTIL, TOW, 1 1/4 TON W/EQUIP HMMWV	0	8	0	0	0	**8**
D1158	TRK, UTIL, CARGO TRP 1 1/4 TON, HMMWV	21	46	4	30	3	**104**
D1159	TRK, UTIL, ARMT CARR W/SA 1 1/4 TON HMMWV	0	13	1	4	0	**18**
D1161	INTERNALLY TRANSPORTABLE VEHICLE (ITV)	0	10	0	0	0	**10**
D1213	MTVR WRECKER	0	0	0	1	0	**1**

TAMCN	NOMENCLATURE	CE	GCE	ACE	LCE	NSE	ESG TOTAL
DX101	HMMWV (MANPADS)	0	0	5	0	0	**5**
E0671	LW155, HOWITZER M777	0	4	0	0	0	**4**
E06X2	EXPED FIRE SUPPORT SYSTEM (EFSS)	0	2	0	0	0	**2**
E06X2M	ITV EFSS	0	4	0	0	0	**4**
E06X2T	TRAILER, EFSS, AMMO	0	2	0	0	0	**2**
E0857	EXPED FIGHTING VEHICLE (PERS)	0	13	0	0	0	**13**
E0858	EXPED FIGHTINGVEHICLE (CMND)	0	1	0	0	0	**1**
E0946	LAV COMMAND AND CONTROL (BN)	0	1	0	0	0	**1**
E0947	LIGHT ARMORED VEHICLE	0	4	0	0	0	**4**
E0948	LAV, LOGISTICS	0	1	0	0	0	**1**
E0950	LAV MAINTENANCE/RECOVERY	0	1	0	0	0	**1**
E1378	RECOVERY VEH, FULL TRAC, MEDIUM	0	0	0	1	0	**1**
E1888	TANK, COMBAT, FT, 120MM GUN	0	4	0	0	0	**4**
E1906	TRUCK, DSETS	0	0	0	1	0	**1**
K4234	PTM	0	0	0	0	1	**1**
XXXX	RHIB, 24 Ft, w/ TLR	0	0	0	0	1	**1**
ZUAVC	UAV GCS GROUND CONTROL STA HMMWV	0	0	1	0	0	**1**
ZUAVD	UAV GDT HMMWV	0	0	1	0	0	**1**
	TOTAL:	**83**	**212**	**67**	**229**	**18**	**609**

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